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ABSTRACT: *Forty-two species of Ostracoda are recorded from the Lizard Springs formation, from Kugler's Bed 3 on Soldado Rock, from the Marac Quarry, and from core samples from deep borings. Thirteen new species or subspecies are described, and one new generic name is proposed. Fifteen species recorded here have previously been described from the United States Gulf Coast or from Central America. The faunas from Soldado Rock, Marac Quarry, and the core samples show similarity to the fauna of the Guasare limestone of Venezuela. On the basis of combined evidence from pelagic foraminifera and Ostracoda, these beds are correlated with the basal Lizard Springs.*

Ostracoda from the Paleocene of Trinidad

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INTRODUCTION

"Little attention seems to have been paid to the Ostracoda, either Recent or fossil, of the West Indies." This statement of R. J. L. Guppy (1893) is still true after sixty years, but an attempt will be made to remedy this lack in a planned series of publications on the fossil Ostracoda of Trinidad, of which this is the first paper. Originally, it was intended to publish the complete series as an appendix to Dr. H. G. Kugler's forthcoming treatise on the geology of Trinidad, but the amount of space needed for adequate descriptions makes it desirable to publish the study of the ostracodes separately.

The writer wishes to express his gratitude to Dr. Kugler and to the management of Trinidad Leaseholds Limited (T.L.L.), now Trinidad Oil Company, Ltd., for submitting to him all their material on ostracodes. He also wishes to thank the management of The United British Oilfields of Trinidad, Limited (U.B.O.T.), now Shell Trinidad Ltd., for permitting publication of the results of this study, which includes many samples belonging to their collections.

Type specimens of the new species and subspecies described in this paper, as well as some of the other figured specimens, have been deposited in the United States National Museum, Washington, D. C.

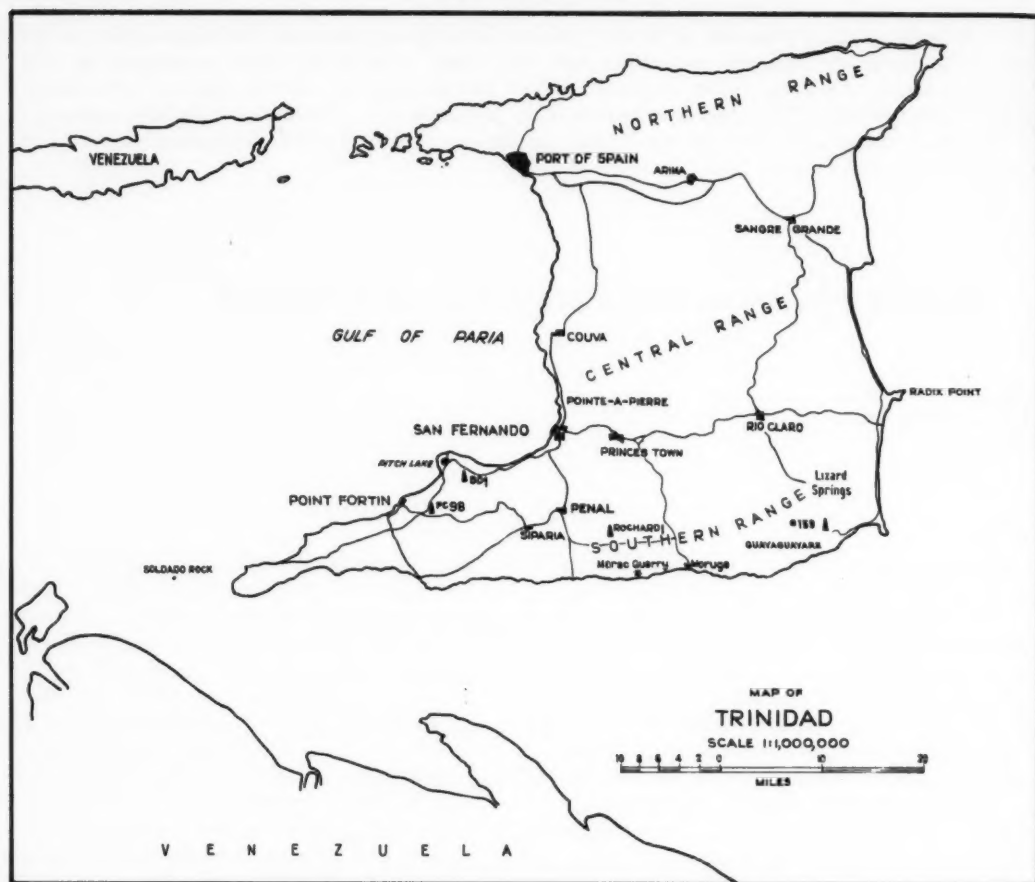
The Ostracoda described in this paper were found in samples from the following localities:

- 1) Type locality of the Lizard Springs formation, in the valley of the River Ampelu in southeastern Trinidad. Samples: Renz 285 and 289; Barr 6972; and Kugler 3460A. Additional samples from other localities are: Kugler 9415, a large slip-

-mass in the Nariva formation, south of the railway station at Pointe-a-Pierre; Kugler 10832, a slip-mass in the Nariva formation at Pointe-a-Pierre; Hawkins 1831, a slip-component in the Miocene of Carmen Jones Ravine, Moruga area; and core samples from U.B.O.T.'s well Boodoosingh (BD) 1, two miles east of the Pitch Lake, and from T.L.L.'s well Guayaguayare (G) 159, in southeastern Trinidad. The Lizard Springs type locality was described by Cushman and Renz (1946). The modern zonation of the formation, which differs from that of Renz, has been provided by H. Bolli (publication in press), and can be seen in Table 1.

- 2) Kugler's Bed 3 on Soldado Rock. Samples: Kugler 2950 and 2951; Grimsdale 31; and Cummings 35 and 40. For a description of this locality, see Kugler (1938).
- 3) Marac Quarry. Samples: P. Moore 1863 and 1864; Gansser 69 and 73 (the latter representing material from the interior of a *Hercoglossa*); Kugler 7908 and 9427; and van den Bold 126. The locality is described by Liddle (1946, p. 729).
- 4) Core samples from 11,000-11,042 feet in U.B.O.T.'s well FC-98, in the Point Fortin field. On the basis of the mollusks, Terpstra (private report, U.B.O.T.) correlates these beds with the Soldado formation and the Marac limestone.
- 5) Core samples from 8556-8571 feet in T.L.L.'s well Rochard (R) 1, 3.8 miles northwest of Marac Quarry, in southern Trinidad.

Cushman and Jarvis (1928) considered the Lizard Springs formation to be Upper Cretaceous in age, but according to Cushman and Renz (1946), the



TEXT-FIGURE 1

formation "occupies a transitional zone between the late Cretaceous and early Tertiary." Grimsdale (1947) and Bolli (1952) each suggest an early Tertiary age. Bolli compares Kugler's Bed 3 of Soldado Rock, the fauna of which was described by Cushman and Renz (1942), with the lower Lizard Springs; Bronnimann (1952), on the other hand, points to the relationship of this bed with the upper part of the Lizard Springs formation. According to Vaughan and Cole (1941), the larger foraminifera in Kugler's Bed 3 compare with those of the Lower Eocene Nanafalia formation of Alabama.

Kugler's Bed 3 on Soldado Rock was included by Kugler (1938) in Maury's Soldado formation, although Maury (1925) established the name only for Beds 1 and 2. Later, Kugler (1953, p. 39) separated Kugler's Bed 3 from the Soldado formation and considered the rich fauna of smaller foraminifera of Midwayan aspect to have been reworked.

The Ostracoda of Kugler's Bed 3 are usually not very well preserved, but are no more poorly preserved than those from the Marac Quarry, and there is no real indication of reworking. The specimens from the core samples are, of course, better preserved, since they have not been exposed to weathering.

The Ostracoda from Kugler's Bed 3 on Soldado Rock, from the Marac Quarry, and from the core samples from wells FC-98 and Rochard 1 show affinity to the Midway fauna of the United States Gulf Coast and to the Ostracoda of the Guasare limestone of western Venezuela. In this connection it should be pointed out that the Ostracoda of the Guasare formation, with which the Trinidadian specimens have been compared, are from the "Cytherella limestone" of the Guasare formation in wells in the Mara and La Paz fields, west of Maracaibo.

TABLE 1

3

The fauna of the Lizard Springs formation is quite different, however, which is not surprising, in view of its deeper-water facies as compared with the shallow-water facies of the other formations. This deep-water character is also indicated by the abundance of specimens of the genus *Krithe*. Species of this genus are the most common ostracodes in the bathyal Cipero and Lengua formations of the Trinidad Miocene. Most of the species in the Lizard Springs are long-ranging and occur also in the Lower and Middle Eocene Navet formation and in younger beds.

A sample from T.L.L.'s collections (LS 102) has yielded a fauna that appears to be intermediate between the Lizard Springs and Soldado faunas: *Bairdia cespicedensis* van den Bold, *Hermanites collei* (Gooch)?, *Cythereis?* *trinidadensis* n. sp., *Trachyleberis?* *spinossissima* (Jones and Sherborn), *Trachyleberis?* sp., and *Cytheretta arrugia* n. sp. have been identified. Aside from the fact that it is labelled "Lizard Springs," nothing is known about the location of this sample, and it has not been included in Table 1.

The presence of pelagic foraminifera in the core sample from well Rochard 1 is of special interest, as they make it possible to correlate the fauna with that of the basal Lizard Springs (Bolli, publication in press). This would also place the closely related faunas of the Marac Quarry and of the core samples from well FC-98, and probably also the fauna of Kugler's Bed 3, at the base of the Lizard Springs formation. Unfortunately, Kugler's Bed 3 had disappeared from Soldado Rock when the writer visited it in the spring of 1952, so that it is now impossible to collect more material.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA

Suborder PLATYCOPA

Family CYTHERELLIDAE

Genus PLATELLA Coryell and Fields, 1937

Platella kelleltae Munsey

Plate 1, figure 2a-b

Platella kelleltae MUNSEY, 1953, Jour. Pal., vol. 27, p. 5, pl. 1, fig. 4.

In the Guasare formation, the carapace exhibits the reticulations described by Munsey, but the Trinidad specimens often appear nearly smooth because of poor preservation. They differ from the original description

in the greater thickness of the shell, which may be the result of a higher calcium content of the environment. This species, which was originally described from the Paleocene Coal Bluff member of the Naheola formation of Alabama, occurs regularly in the samples from Soldado Rock and in the Guasare of Venezuela, and has also been found in Marac Quarry and in the core samples from well FC-98.

Dimensions: Length 0.67 mm.; height 0.34 mm.; width 0.26 mm.

Genus CYTHERELLA Jones, 1849

Cytherella guasarensis van den Bold, new species

Plate 1, figure 1a-d

Female: Carapace ovate, highest slightly in front of the middle, widest behind the middle. Dorsal margin gently arched; ends rounded, the posterior one more obliquely and with an obtuse angle above the middle; ventral margin convex.

Male: Carapace elongate-subquadrangular, highest behind the middle. Dorsal and ventral margins nearly straight and converging anteriorly. Posterior end obliquely rounded as in the female.

<i>Dimensions:</i>	Length	Height	Width
Female	0.63 mm.	0.43 mm.	0.30 mm.
Male	0.55 mm.	0.34 mm.	0.26 mm.

This species resembles *Cytherella tumidosa* Alexander (1934, p. 209, pl. 32, figs. 1-2, 5-6; pl. 35, figs. 3-4) in side view, but the shape of the posterior end is different in dorsal view. *Cytherella complanata* (Reuss), figured by Alexander (1932, p. 305, pl. 28, figs. 3-4) as *Cytherella bullata* Alexander (see Alexander, 1934, p. 209, footnote), is very similar in the female form, but the male is different in dorsal view. This species has been found in the core samples from well FC-98 and in the Guasare formation of Venezuela.

Holotype: A complete carapace of a female from well FC-98, core at 11,020-11,033 feet; U. S. Nat. Mus. no. 562029.

Cytherella sp.

Plate 2, figure 1

Carapace elongate-ovate, highest in front of the middle, widest just behind the middle. Shaped like the preceding species, but larger and more elongate.

Dimensions: Length 1.19 mm.; height 0.74 mm.

This species occurs in the Lizard Springs formation at the type locality. It has also been found in the Middle and Lower Eocene Navet formation (Navet marl, Dunmore marl, Friendship Quarry marl, and Ramdat marl; the latter is considered by Bolli to belong to the upper part of the Lizard Springs formation).

TRINIDAD PALEOCENE OSTRACODA

Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea sp.

Plate 4, figure 1

Carapace subrectangular. Dorsal and ventral margins in the right valve almost straight and parallel, in the left valve slightly sinuate. Ornamentation consists of three longitudinal ridges which join with a vertical ridge-like swelling at the posterior end. The middle one of these ridges is sinuate.

Dimensions: Length 0.53 mm.; height 0.30 mm.

This species is rather similar to *Cytherelloidea tolletensis* Sexton (1951, p. 812, pl. 117, figs. 3, 6) from the lower Taylor formation of Arkansas, to *Cytherelloidea howei* Swain (1948, p. 190, pl. 12, fig. 5) from the Lower Eocene of Maryland, and to *Cytherelloidea smithvillensis* Howe (1934, p. 30, pl. 5, fig. 3), from the Middle Eocene Claiborne group. In all of these species, the longitudinal ridges are separated in front, but in this species they merge gradually. Moreover, the ornamentation in our species is identical in both valves, whereas in Sexton's and Howe's species the ornamentation is different in the right and left valves. The species occurs rarely on Soldado Rock and in the cores from well FC-98, but not enough well-preserved specimens are present to give it a new specific name.

Suborder PODOCOPA

Family CYPRIDIDAE

Subfamily PONTOCYPRIDINAE

Genus PROPONTOCYPRIS Sylvester-Bradley, 1947

Propontocypris sp.

Plate 1, figure 3a-b

A number of small forms in the samples from Soldado Rock have been referred to this genus. It is not certain that they all belong to the same species.

Dimensions: Length 0.45 mm.; height 0.25 mm.

Genus ARGILLOECIA Sars, 1866

Argilloecia subcylindrica Alexander

Argilloecia subcylindrica ALEXANDER, 1934, Jour. Pal., vol. 8, p. 214, pl. 32, fig. 17; pl. 35, fig. 16. - VAN DEN BOLD, 1946, *Contribution to the Study of Ostracoda*, p. 64, pl. 2, fig. 10.

Only one specimen of this species, originally described from the Midway of Texas and later reported from the Paleocene and Lower Eocene of Guatemala, was found in the Lizard Springs formation.

Subfamily CANDONINAE

Genus PARACYPRIS Sars, 1866

Paracypris communis van den Bold

Plate 2, figure 12a-b

Paracypris communis VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 66, pl. 2, fig. 11.

This species from the Lower Eocene and Paleocene of Guatemala and British Honduras occurs rather regularly on Soldado Rock and in the Guasare formation of Venezuela. One specimen was found in a sample from Marac Quarry.

Dimensions: Length 0.69 mm.; height 0.30 mm.; width 0.20 mm.

Paracypris aff. *limburgensis* van Veen

Plate 2, figure 11

Paracypris limburgensis VAN VEEN, 1934, Natuurh. Maandblad, vol. 23, p. 2, pl. 1, figs. 10-18.

Paracypris aff. *limburgensis* van Veen. - VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 65, pl. 4, fig. 1.

The form from Trinidad is higher anteriorly than either the Dutch or the Central American specimens. It was found only in T.L.L.'s well Rochard 1, and there were not enough specimens to warrant a new specific name.

Dimensions: Length 0.74 mm.; height 0.36 mm.; width 0.30 mm.

Family BAIRDIIDAE

Genus BAIRDIA McCoy, 1844

Bairdia dolicha van den Bold, new species

Plate 2, figure 2a-b

Carapace elongate in side view, rather thick-set in dorsal view. Greatest height and width in the middle. Dorsal margin a low arch, ventral margin sinuate, posterior end rather sharply pointed, anterior end rounded regularly below the rather low anterior cardinal angle.

Dimensions: Length 0.83 mm.; height 0.43 mm.; width 0.45 mm.

The species was found on Soldado Rock, in Marac Quarry, in the Middle Eocene Navet formation of Friendship Quarry, and (probably reworked) in the Upper Eocene of Soldado Rock. It is one of the most common ostracodes in the Guasare formation of the oil fields west of Lake Maracaibo, Venezuela.

Holotype: A complete carapace from Cummings (RHC) sample 35, on Soldado Rock; U. S. Nat. Mus. no. 562030.

***Bairdia soldadensis* van den Bold, new species**

Plate 2, figure 3a-b

Carapace highest in front of the middle, widest behind the middle. In side view, the dorsal margin is strongly arched, slightly angled at the greatest height and in the middle of the posterior slope. In the right valve the greatest height lies more to the anterior. Anterior end low, rounded; posterior end acutely angled below the middle. Ventral portion of the carapace rather flattened. In dorsal view the posterior end is slightly produced in the left valve.

Dimensions: Length 0.78 mm.; height 0.44 mm.; width 0.40 mm.

The species occurs regularly on Soldado Rock, and one specimen was identified with certainty in a sample from Marac Quarry. A very similar and probably the same species occurs in the Guasare formation of western Venezuela.

Holotype: A complete carapace from Cummings (RHC) sample 35, on Soldado Rock; U. S. Nat. Mus. no. 562031.

***Bairdia* aff. *hondurasensis* van den Bold**

Plate 2, figure 4a-b

Bairdia hondurasensis VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 71, pl. 4, fig. 6.

The form from the Guasare formation of Venezuela and from Soldado Rock is probably no more than a variant of *Bairdia hondurasensis*, which was described from the Lower Eocene of Guatemala and British Honduras.

Dimensions: Length 0.84 mm.; height 0.53 mm.; width 0.46 mm.

Figured specimen: A complete carapace from Cummings (RHC) sample 35, on Soldado Rock; U. S. Nat. Mus. no. 562043.

***Bairdia cespedecensis* van den Bold**

Plate 2, figure 5a-b

Bairdia cespedecensis VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 73, pl. 1, fig. 8.

This species, which was described from the Upper Cretaceous of Cuba and has also been reported questionably from the Eocene there, occurs in Trinidad in the Lizard Springs formation, the Navet formation, the Upper Eocene of Soldado Rock, and the Cipero and Brasso formations (Oligocene and Lower Miocene).

Dimensions: Length 1.30 mm.; height 0.90 mm.; width 0.65 mm.

Figured specimen: A complete carapace from Cummings (RHC) sample 1048, Navet formation, San Fernando Bypass; U. S. Nat. Mus. no. 562044.

***Bairdia exoura* van den Bold, new species**

Plate 2, figure 6

Carapace of very characteristic shape, highest in front of the middle. Anterior portion almost semicircular; posterior portion produced into a slightly upwardly deflected caudal process. Anterior cardinal angle in the left valve scarcely noticeable, in the right valve above the middle.

Dimensions: Length 1.20 mm.; height 0.70 mm.

This species shows some similarity to *Bairdia cassida* van den Bold (1946, p. 70, pl. 1, fig. 7), but differs in being relatively higher and in the more rounded shape of the anterior end. It is probably related to *Bairdia cespedecensis* van den Bold, and has the same range as that species.

Holotype: A complete specimen from the Navet formation of the San Fernando Bypass, Cummings (RHC) sample 1048; U. S. Nat. Mus. no. 562032.

***Bairdia* sp.**

Plate 2, figure 7

Carapace almond-shaped, laterally compressed, reminiscent of *Bythocypris*. This characteristic species was found in the Guasare limestone and on Soldado Rock. However, there are not enough specimens available from Soldado Rock to establish a new species.

Dimensions: Length 0.83 mm.; height 0.58 mm.; width 0.37 mm.

***Bairdia* spp.**

Plate 2, figure 8

Specimens of *Bairdia* of this general shape occur regularly in the Guasare formation and on Soldado Rock. They show some variation, and probably do not belong to a single species.

Dimensions: Length 0.69 mm.; height 0.42 mm.

Genus BYTHOCYPRIS Brady, 1880***Bythocypris guppyi* van den Bold, new species**

Plate 2, figure 9

Carapace elongate almond-shaped, highest behind the middle, narrow in dorsal view. Anterior end regularly rounded; dorsal margin nearly straight, slightly sinuate; ventral margin slightly sinuate, diverging posteriorly; posterior end obliquely truncate above, narrowly rounded below. Left valve overlapping the right along the dorsal margin, the posterior end, and the greater part of the ventral margin.

Dimensions: Length 0.85 mm.; height 0.42 mm.; width 0.34 mm.

The shape of this species is reminiscent of *Bythocypris* sp. van den Bold (1946, p. 68, pl. 3, fig. 11) from the Miocene of Cuba, but the overlap of the left valve is

TRINIDAD PALEOCENE OSTRACODA

different, and the dorsal margin in that species is more of a flat arch. The species is named in honor of R. J. L. Guppy, who was the first to draw attention to the Ostracoda of Trinidad. Two specimens of this species were found in the Lizard Springs formation; it is more common in the Navet formation (Lower and Middle Eocene).

Holotype: A complete carapace from the Navet formation of the San Fernando Bypass, Cummings (RHC) sample 1048; U. S. Nat. Mus. no. 562033.

Bythocypris? sp.

Plate 2, figure 10a-b

Carapace small; height about equal slightly behind and in front of the middle; carapace somewhat compressed in the middle. Anterior end obliquely rounded; dorsal and ventral margins sinuate and subparallel; posterior end obliquely truncate above, rounded below. Carapace rather thick for the genus in dorsal view, widest near posterior end. Left valve with strong overlap, visible in dorsal view quite near anterior end. In side view left valve can be seen overlapping right along almost entire margin, except anteroventrally.

Dimensions: Length 0.59 mm.; height 0.29 mm.; width 0.25 mm.

The general shape of this species recalls *Argilloecia*, but in that genus the right valve overlaps the left. Only two specimens of this very distinctive species were found in the Lizard Springs formation. It has not been found elsewhere.

Family CYTHERIDAE

Subfamily CYTHERIDEINAE

Genus EUCYTHERE Brady, 1868

Eucythere sp.

Plate 1, figure 4

One specimen of a small species of *Eucythere* was found on Soldado Rock. It is figured here for comparison.

Dimensions: Length 0.39 mm.; height 0.23 mm.

Genus KRITHE Brady, Crosskey and Robertson, 1874

Krithe guatemalensis van den Bold

Plate 1, figure 5a-e

Krithe guatemalensis VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 77, pl. 17, figs. 7-8.

?*Krithe cancuensis* VAN DEN BOLD, 1946, *ibid.*, p. 77, pl. 17, fig. 6.

It is possible that the male of this species was described under the name *Krithe cancuensis*, but as there are a few minor points of dissimilarity, it is thought necessary to give a new description.

Female: Carapace ovate, highest in the middle; dorsal margin arched; depression of the anterodorsal margin in the right valve stronger than in the male. Ventral margin convex; posterior end truncate, not so strongly produced as in the male.

Male: Carapace elongate-ovate; dorsal margin obtusely angled at about one-third the distance from the posterior end, which is obliquely truncate; ventral margin slightly convex.

<i>Dimensions</i> :	Length	Height	Width
Female	0.64 mm.	0.36 mm.	0.27 mm.
Male	0.75 mm.	0.35 mm.	0.27 mm.

It is difficult to distinguish the male of this species from the male of another species occurring in the Lengua and Cipero formations. The dimensions given in the original description of *Krithe guatemalensis* are much smaller than those of the Trinidad specimens; however, the length of the specimen figured in pl. 17, fig. 8 (van den Bold, 1946), is about 0.58 mm., which brings it closer to the dimensions given here. In Trinidad the species occurs abundantly at the Lizard Springs type locality, but has also been found in the Navet formation.

Figured specimens: Four separate valves and one complete carapace from Barr sample 6972, Lizard springs; U. S. Nat. Mus. no. 562046.

Subfamily CYTHERINAE

Genus CYTHEROMORPHA Hirschmann, 1909

Cytheromorpha sp.

Plate 4, figure 2

Only two specimens of a species of *Cytheromorpha* were found on Soldado Rock. One of them is figured for comparison.

Dimensions: Length 0.49 mm.; height 0.25 mm.

Genus Munseyella van den Bold, new name

Toulminia MUNSEY, 1953, *Jour. Pal.*, vol. 27, p. 6 (not *Toulminia* Zittel, 1878).

The generic name *Toulminia* Munsey, 1953 (type: *Toulminia hyalokystis* Munsey, 1953), is preoccupied by *Toulminia* Zittel, 1878, a sponge. Mr. Munsey has agreed (letter dated Jan. 23, 1956) to the renaming of his genus, for which the new name *Munseyella* is here proposed.

Munseyella hyalokystis (Munsey)

Toulminia hyalokystis MUNSEY, 1953, *Jour. Pal.*, vol. 27, pp. 6-7, pl. 2, figs. 26-27; text-fig. 1.

A few specimens of this species were found on Soldado Rock. Other species of this genus are common in younger formations in Trinidad, and will be described in other papers.

Dimensions: Length 0.30 mm.; height 0.21 mm.; width 0.18 mm.

Subfamily TRACHYLEBERINAE

Genus BUNTONIA Howe, 1935

Buntonia alabamensis (Howe and Pyeatt)

Cythereis? alabamensis HOWE AND PYEATT, in HOWE AND GARRETT, 1934, Louisiana, Dept. Cons., Geol. Bull., no. 4, p. 50, pl. 4, figs. 2, 5, 7-10.

Pyricythereis alabamensis (Howe and Pyeatt). - STEPHENSON, 1944, Jour. Pal., vol. 18, p. 453 (part.). - VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 103, pl. 11, fig. 6. - STEPHENSON, 1946, Jour. Pal., vol. 20, p. 330, pl. 42, fig. 12.

This species has been found in well FC-98, in Marac Quarry, in T.L.L.'s well Rochard I, in the "Gaudryina beds" of the Lower or Middle Eocene in U.B.O.T.'s well Nariva Cocal I on the east coast of Trinidad nine miles north of Radix Point, and in the same beds in Trinidad Petroleum Development Company Limited's (T.P.D.) well Esmeralda I, north of Princes Town, Trinidad. It is common in the Guasare formation of western Venezuela. It has previously been described from the Lower and Middle Eocene of the United States Gulf Coast and the Lower Eocene and Paleocene of Guatemala and British Honduras.

Dimensions: Length 0.62 mm.; height 0.33 mm.; width 0.28 mm.

Genus CYTHEREIS Jones, 1849

Cythereis? trinidadensis van den Bold, new species

Plate 3, figure 1a-d

Carapace short, highest near the anterior end at the anterior cardinal angle, which projects strongly in the left valve. Anterior end very broadly rounded, denticulate; dorsal margin straight, partly obscured by several spinose ridges; posterior end bluntly rounded; ventral margin convex. Ornamentation consists of a broad, flat anterior rim, which exhibits shallow reticulations and continues parallel to the ventral margin and also forms the posterior rim, which bears a few spines. Muscle-scar area elevated, knob-like; a reticulation extends out from this area into the anterior portion of the carapace. This subcentral swelling is connected by ridges to the two most anterior of the three dorsal ridges, both of which have sharp peaks. A broad ventral ridge forms a rather wide swelling, in which some shallow parts suggest reticulation. At its posterior end it is connected to the third dorsal ridge, which obscures the posterior cardinal angle. In dorsal view the carapace is thick-set, widest behind the middle, at the end of the ventral ridge. The free margin is characterized by a broad selvage which carries a very narrow groove. The hinge in the right valve has slightly grooved terminal teeth, which are connected by a groove that is very shallow in the middle and deepens toward the ends, especially toward the anterior end, where it forms a small socket. In the left valve, the median hinge-element consists of a low bar, which is narrowest in the middle and bears

a small triangular tooth at the anterior end. In front of this tooth is a large socket, open to the interior and bordered dorsally by a strong ridge, which culminates anteriorly in a knob-like tooth before continuing along the free margin as a selvage. This ridge continues backward as the dorsal margin, separated from the median bar by a faint groove, and borders the posterior socket, there forming the strongly projecting posterior cardinal angle. The muscle-scar area is depressed from the inside, and consists of a rather irregular row of five scars with one V-shaped scar in front.

Dimensions: Length 0.90 mm.; height 0.58 mm.; width 0.44 mm.

From the description of the hinge, it is clear that this species cannot be assigned directly to any described genus of the Trachyleberinae. Because of the crenulate anterior tooth, it is very close to *Cythereis*, but differs in the peculiar development of an extra tooth in front of the anterior socket of the left valve. However, it appears unwise to base a new genus in this very complicated group upon one species alone.

Cythereis? trinidadensis has a superficial resemblance to *Cythereis hazeli* van den Bold (1946, p. 92, pl. 10, fig. 4), which also occurs in the Oligocene and Miocene of Trinidad. The species is long-ranging. Only a few specimens were found at the Lizard Springs type locality, but it occurs also in the Lower and Middle Eocene Navet formation, the Upper Eocene San Fernando formation, and the Oligocene and Miocene Cipero formation. One specimen was found in the Upper Cretaceous Pointe-a-Pierre Railway Cut marl (Renz, 1942).

Holotype: One complete carapace from Cummings (RHC) sample 1047, San Fernando Bypass, Navet formation; U. S. Nat. Mus. no. 562037.

Cythereis? sculptilis Alexander

Plate 3, figure 2a-b

Cythereis sculptilis ALEXANDER, 1934, Jour. Pal., vol. 8, pp. 221-222, pl. 32, fig. 13.

?*Cythereis* aff. *sculptilis* Alexander. - SWAIN, 1946, Jour. Pal., vol. 20, pp. 377-378, pl. 54, fig. 5.

This species has a general resemblance to *Cytherina semiplicata* Reuss (1846, p. 104, pl. 24, fig. 16) and to *Cythereis bonnemai* Triebel (1940, p. 204, pl. 7, figs. 67-70), species which belong to the genus *Cythereis* Jones, emend. Triebel, not only in general appearance but also in the development of the marginal area. The hinge-teeth are not crenulated, however, and accordingly the species should not be referred to *Cythereis* proper. At present there is no genus to which it could be assigned, and, short of making it the type species of a new genus, the best procedure seems to be to refer it questionably to *Cythereis*. The species occurs fairly regularly in the Lizard Springs formation.

Dimensions: Length 0.80 mm.; height 0.46 mm. (quite variable).

TRINIDAD PALEOCENE OSTRACODA

Genus PURIANA Coryell and Fields, 1953

Puriana? sp.

Plate 3, figure 9a-b

Carapace elongate, subrectangular in side view, thick-set in dorsal view. Anterior end rounded, with thickened rim; dorsal and ventral margins slightly sinuate and subparallel; posterior end truncate above, rounded below. Ventral portion of the carapace swollen and slightly flattened, causing the ventral ridge to project in dorsal view. Subcentral tubercle slightly elevated. Surface covered with obscure reticulations, pits, and a faint pattern of low nodes grouped in posteriorly diverging rows.

Dimensions:	Length	Height	Width
Female (?)	0.55 mm.	0.31 mm.	0.32 mm.
Male (?)	0.61 mm.	0.31 mm.	0.31 mm.

The general ornamentation and shape is reminiscent of *Puriana* and also of *Murrayina* Puri, 1953. As the interior could not be studied, the generic assignment must be left undecided. The species occurs on Soldado Rock and in the Guasare formation of western Venezuela.

Figured specimen: A complete carapace from Grimsdale sample 31, on Soldado Rock; U.S. Nat. Mus. no. 562042.

Genus PTERYGOCYTHEREIS Blake, 1933

Pterygocythereis sp.

Plate 4, figure 6a-b

Carapace elongate, alate, the ala nearly always damaged. Anterior end rounded and denticulate, with a slightly thickened rim; anterior cardinal angle prominent; dorsal and ventral margins nearly straight and converging rather strongly posteriorly; posterior end truncate; posterior cardinal angle sharp. Some depressions in the ala suggest reticulation. Below the ala there is another weaker and thinner ridge parallel to it. The species has been found only on Soldado Rock.

Dimensions: Length 0.64 mm.; height 0.36 mm.; width 0.28 mm.

Genus TRACHYLEBERIS Brady, 1898

Trachyleberis? *spinossissima* (Jones and Sherborn)

Plate 3, figure 4a-b

Cythereis spinossissima JONES AND SHERBORN, 1887, Geol. Mag., new ser., dec. 3, vol. 4, p. 452, text-fig. 2 (not *Cythereis spinossissima* BRADY, 1865, Zool. Soc. London, Trans., vol. 5, p. 386 = *Cythereis mucronata* SARS, 1866, Forh. Vidensk.-Selsk. Christiania, aar 1865, p. 386 = *Pterygocythereis*).

Cythereis spiniferrima JONES AND SHERBORN, 1888, Palaeontogr. Soc. London, Monogr., vol. 42, p. 34, text-fig. 3. - ALEXANDER, 1934, Jour. Pal., vol. 8, p. 220, pl. 32, fig. 11. - LATHAM, 1938, Proc. Roy. Soc. Edinburgh, vol. 59, p. 43, text-fig. 6. - KLINE, 1942, Mississippi, Geol. Survey, Bull., no. 53, p. 68, pl. 8, fig. 6. - VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, p. 93, pl. 13, fig. 3. -

SWAIN, 1948, Maryland, Dept. Geol., Mines and Water Resources, Bull., no. 2, p. 205, pl. 13, fig. 8.

Trachyleberis spiniferrima (Jones and Sherborn). - BOWEN, 1953, Proc. Geol. Assoc., vol. 64, p. 288.

? *Cythereis reticulodacyi* Swain. - MUNSEY, 1953, Jour. Pal., vol. 27, p. 9, pl. 4, figs. 1-2, 8, 15-16.

Even in the best preserved specimens, the spines on the lateral surface and on the anterior rim are only vaguely indicated, and appear to have been abraded off. This species has been described from the London Clay of England, the Midway of the United States Gulf Coast, and the Paleocene of Guatemala and British Honduras. It occurs on Soldado Rock, in the core sample from well Rochard 1, and in the Guasare formation of western Venezuela.

Dimensions: Length 0.69 mm.; height 0.35 mm.; width 0.36 mm.

Trachyleberis? sp.

Plate 3, figure 5a-b

Only five closed carapaces of this spinose form have been found, four in the Lizard Springs formation and one in the Navet. It may be a new species, or it may be identical with one of the spinose species described from the Lower and Middle Eocene of the United States Gulf Coast, but we have failed to find one that does not differ in one or more characteristics. As the material is insufficient to establish a new species, the description is omitted, and one specimen is figured for comparison.

Dimensions: Length 0.79 mm.; height 0.45 mm.; width 0.36 mm.

Genus ISOCYTHEREIS Triebel, 1940

Isocythereis? aff. *fissicostis* Triebel

Plate 3, figure 3a-b

Isocythereis fissicostis TRIEBEL, 1940, Senckenbergiana, vol. 22, no. 3/4, pp. 209-211, pl. 7, figs. 71-74; pl. 10, fig. 108.

Three complete carapaces and a single right valve were found in the Lizard Springs formation. The only difference between this form and the genotype of *Isocythereis* lies in the length of the ventral ridge, which in our species extends farther anteriorly.

Dimensions: Length 0.91 mm.; height 0.46 mm.

Subfamily HEMICYTHERINAE

Genus HERMANITES Puri, 1955

Hermanites collei (Gooch)?

Plate 3, figure 6a-b

Cythereis collei GOOCH, 1939, Jour. Pal., vol. 13, p. 585, pl. 67, fig. 19. - VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, p. 94, pl. 11, fig. 4. - BLAKE, 1950, Jour. Pal., vol. 24, p. 178, pl. 30, figs. 30-32.

The connecting ridge between the dorsal and ventral ridges is not so pronounced as in the specimens figured by Gooch. Specimens from the Salt Mountain limestone

of Alabama which very probably belong to this species are identical with ours. Here also, the subcentral node is slightly less pronounced. The species has been found on Soldado Rock, and single specimens have been encountered in samples from Marac Quarry and in the cores from well FC-98.

Dimensions: Length 0.66 mm.; height 0.36 mm.; width 0.31 mm.

Figured specimen: A complete carapace from Kugler sample 2951, on Soldado Rock; U. S. Nat. Mus. no. 562045.

***Hermanites? grimsdalei* van den Bold, new species**
Plate 3, figure 7a-b

Carapace elongate-subquadrate, highest at anterior cardinal angle. Anterior end broadly rounded, formed by a broad, flat rim which continues along the ventral margin, the posterior end, and the dorsal margin; dorsal and ventral margins nearly straight and converging gradually posteriorly; posterior end short, angled below the middle, concave above, truncate below. Dorsal margin partly obscured by a dorsal ridge, which is linked at the posterior end to an oblique, rather obscure median ridge extending backward from the well developed subcentral tubercle. In front of this node are two raised ridges. Ventral ridge short, accompanied by a row of nodes below it. The surface is rather strongly reticulate in the neighborhood of the ridges; farther away from them, the reticulation becomes rather obscure.

Dimensions: Length 0.80 mm.; height 0.41 mm.; width 0.38 mm.

This species may be ancestral to *Cythereis? vicksburgensis* Howe (Howe and Law, 1936, p. 34, pl. 4, fig. 4; pl. 5, figs. 1-2), which occurs in the Trinidad Oligocene and Miocene. The species is named in honor of T. F. Grimsdale. It was found only on Soldado Rock.

Holotype: A complete carapace from Grimsdale (G) sample 31, from Kugler's Bed 3 on Soldado Rock; U. S. Nat. Mus. no. 562038.

Subfamily BRACHYCYTHERINAE

Genus BRACHYCYTHERE Alexander, 1933

***Brachycythere maerkyi* van den Bold, new species**
Plate 3, figure 8a-b

Carapace ovate, alate, highest near the anterior end, widest at the posterior end of the ala, behind the middle. Anterior end obliquely rounded, bearing a number of rounded teeth in the lower half; dorsal margin very slightly convex in the left valve, straight in the right one; posterior end bluntly angled below the middle, strongly compressed in dorsal view. The ala forms a flattened rim along the swollen ventral portion of the carapace, which is thickest only very slightly behind the middle. Near the anterior end, the ala exhibits a narrow, curved depression, as in *Brachycythere plena*

Alexander (Alexander, 1934, pl. 33, fig. 6). The anterior end carries a thin, rather flat rim, which is denticulate in the lower part and continues into the ala.

Dimensions: Length 1.04 mm.; height 0.64 mm.; width 0.85 mm.

This species is named in honor of Dr. R. Maerky, who discovered the Lizard Springs type locality, from which this species is described. It occurs also in the Navet formation, of Lower to Middle Eocene age.

Holotype: A complete carapace from Barr (B) sample 6972, upper Lizard Springs formation; U. S. Nat. Mus. no. 562034.

***Brachycythere? kugleri* van den Bold, new species**
Plate 4, figure 7a-b

Carapace ovate, highest in front of the middle. Anterior end obliquely rounded; dorsal margin almost straight; ventral margin convex; posterior end angled in the middle, convex below, straight above in the left valve, slightly concave in the right. Dorsal margin in the right valve slightly sinuate, with posterior cardinal angle somewhat produced. Left valve overlapping along the dorsal part of the anterior end, where the margin of the right valve is slightly depressed, along the dorsal margin (except for the posterior cardinal angle), along the upper part of the posterior end, and along the greater part of the ventral margin. Dorsal view spindle-shaped with both ends compressed, widest just behind the middle. Sometimes a faint ornamentation of low, longitudinal stripes can be seen. Eye spots small but standing out clearly.

Dimensions: Length 0.79 mm.; height 0.46 mm.; width 0.37 mm.

In general character, this species approaches *Protobuntonia* Gréko (1954, pp. 489-490), but it has a much stronger overlap of the left valve along the dorsal margin, and in this respect shows more relationship to *Brachycythere*. It has been found in well FC-98 in the Point Fortin field, in Marac Quarry, and also, although rarely, in the Guasare formation of Venezuela. The same species has also been found in the Upper Eocene, but there are indications that it is reworked there. The species is named in honor of Dr. H. G. Kugler.

Holotype: A complete specimen from core at 11,020-11,033 feet in well FC-98; U. S. Nat. Mus. no. 562035.

***Brachycythere? kugleri soldadensis* van den Bold, new subspecies**
Plate 4, figure 8a-b

Carapace similar in general shape to the typical form of the species, but the portion in front of the anterior cardinal angle is relatively shorter, and the portion behind is longer and more slender. Posterior end much more sharply pointed than the typical form of the species. Here also, the posterior cardinal angle is the only place where the left valve does not overlap the right.

TRINIDAD PALEOCENE OSTRACODA

Dimensions: Length 0.74 mm.; height 0.44 mm.; width 0.35 mm.

This subspecies was found on Soldado Rock and also (probably reworked) in some Upper Eocene samples.

Holotype: A complete carapace from Grimsdale (G) sample 31, from Kugler's Bed 3 on Soldado Rock; U. S. Nat. Mus. no. 562036.

Brachycythere? kugleri van den Bold var.

Plate 4, figure 9

In this variety the same features of overlap are seen as in the two preceding forms, but this form is much more elongate. Only four specimens of this variety were found on Soldado Rock. It may possibly be the male of *Brachycythere kugleri soldadensis*, but the difference between that subspecies and this variety seems to be more than could be accounted for by sexual dimorphism.

Dimensions: Length 0.81 mm.; height 0.36 mm.

Subfamily CYTHERETTINAE

Genus CYTHERETTA G. W. Müller, 1894

Cytheretta arrugia van den Bold, new species

Plate 3, figure 10a-b

Carapace elongate-rectangular, highest at the anterior cardinal angle, which projects in the left valve and is depressed in the right valve. Dorsal and ventral margins nearly straight and converging slightly posteriorly; posterior end rather regularly rounded in the left valve, in the right one angled below the middle, convex below and concave above. Left valve overlapping the right at anterior and posterior cardinal angles and on the posterior end. Ornamentation consists of a thickened anterior rim, which is faintly reticulate; swollen ventral portion of the carapace flattened, the boundary between ventral and lateral parts forming a thickened ridge; a dorsal ridge is indicated; in between, there are several oblique longitudinal plications, and the surface between is pitted.

Dimensions: Length 0.74 mm.; height 0.39 mm.; width 0.36 mm.

This species is rather similar to *Cytheretta alexanderi* Howe and Chambers (1935, p. 45, pl. 5, figs. 17-21; pl. 6, figs. 27-28), especially as figured by Blake (1950, pl. 30, figs. 1-3), but that species has no anterior rim. More similar is *Cytheretta ramosa ramosa* Triebel (1952, pl. 2, figs. 1-8), but here also, there are conspicuous differences.

The species has been found in well FC-98, and a few specimens were found in the Marac samples. It also occurs in the Guasare formation of Venezuela.

Holotype: A complete carapace from core at 11,000-11,010 feet in well FC-98, Point Fortin; U. S. Nat. Mus. no. 562039.

Genus PARACYTHERETTA Triebel, 1941

Paracytheretta? maracensis van den Bold, new species

Plate 3, figure 11a-b

Carapace elongate-subrectangular, highest one-quarter of the length from the anterior, at the anterior cardinal angle of the left valve. Anterior end rounded, dorsal slope sinuate in the right valve; dorsal margin in right valve straight, in left valve sinuate with projecting posterior cardinal angle; ventral margin almost straight; posterior end angled in the middle, slightly concave above, rounded below. Left valve overlapping right one strongly along dorsal margin and dorsal parts of both ends. Eye spot small but clearly visible. In dorsal view compressed, with subparallel sides. Ornamentation consists of three low longitudinal ridges, between which there is a rather faint reticulation. As no single valves were found, the generic assignment could not be checked.

Dimensions: Length 0.80 mm.; height 0.41 mm.; width 0.32 mm.

This species occurs fairly regularly in well FC-98 and in the Marac Quarry. The same species has been found in the Guasare formation of Venezuela.

Holotype: A complete carapace from core at 11,020-11,033 feet in well FC-98, Point Fortin; U. S. Nat. Mus. no. 562040.

Subfamily LOXOCONCHINAE

Genus LOXOCONCHA Sars, 1866

Loxoconcha nuda Alexander

Plate 4, figure 3

Loxoconcha nuda ALEXANDER, 1934, Jour. Pal., vol. 8, p. 228, pl. 33, fig. 12.

This species has been found occasionally on Soldado Rock. It is slightly larger than the specimens from Texas.

Dimensions: Length 0.48 mm.; height 0.25 mm.; width 0.20 mm.

Subfamily CYTHERURINAE

Genus EUCYTHERURA G. W. Müller, 1894

Eucytherura decorata Weingeist

Plate 4, figure 4

Eucytherura decorata WEINGEIST, 1949, Jour. Pal., vol. 23, p. 373, pl. 73, fig. 9.

As stated by Weingeist, this species is very similar to *Eucytherura claibornensis* Stephenson, *Eucytherura latebrosa* Weingeist, and *Eucytherura stephensoni* Weingeist. The single specimen found on Soldado Rock possesses most of the characteristics by which Weingeist distinguishes *Eucytherura decorata* from the other three species (Weingeist, 1949, p. 377).

Dimensions: Length 0.34 mm.; height 0.22 mm.

Genus CYTHEROPTERON Sars, 1866

Cytheropteron liogluma Munsey
Plate 4, figure 5a-b

Cytheropteron liogluma MUNSEY, 1953, Jour. Pal., vol. 27, p. 17, pl. 3, fig. 22.

This species has been found in wells FC-98 and Rochard 1, and in the Marac Quarry. It is common in the Guasare formation of western Venezuela.

Dimensions: Length 0.54 mm.; height 0.33 mm.; width 0.29 mm.

Subfamily XESTOLEBERINAE

Genus XESTOLEBERIS Sars, 1866

Xestoleberis mauryae van den Bold, new species
Plate 1, figure 6a-b

Carapace ovate, highest slightly behind the middle; dorsal margin arched, ventral margin sinuate, anterior end obliquely rounded, posterior end very broadly rounded. Greatest width behind the middle; posterior end rounded in dorsal view; anterior end acute, compressed. Left valve strongly overlapping the right in the posterior half of the dorsal margin.

Dimensions: Length 0.51 mm.; height 0.30 mm.; width 0.29 mm.

This species is close to *Xestoleberis truncata* Alexander (1934, p. 232, pl. 34, figs. 3-4, 9-10; pl. 35, fig. 7), but differs in having a lower anterior end; in addition, the ventral margin is not convex but is slightly concave in the middle. It is named in honor of the late Dr. Carlotta Maury. The species occurs on Soldado Rock and has also been found in the Guasare formation of Venezuela.

Holotype: A complete carapace from Kugler (K) sample 2950 on Soldado Rock; U. S. Nat. Mus. no. 562041.

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EXPLANATION OF PLATES

PLATE 1

All figures $\times 80$.

- 1 *Cytherella guasarensis* van den Bold, n. sp.
a, left valve view of female carapace. b, dorsal view of same. c, left valve view of male carapace. d, dorsal view of same. Both from 11,020-11,033 feet in well FC-98.
- 2 *Platella kelleltae* Munsey
a, left valve view of complete carapace. b, dorsal view of same. Grimsdale sample 31.
- 3 *Propontocypris* sp.
a, right valve view of complete carapace. b, exterior of right valve. Both from Kugler sample 2950, Soldado Rock.
- 4 *Eucythere* sp.
Right valve view of complete specimen. Kugler sample 2950, Soldado Rock.
- 5 *Krithe guatemalensis* van den Bold
a, exterior of right valve, female. b, exterior of left valve, female. c, exterior of left valve, male. d, dorsal view of complete male specimen. e, exterior of right valve, male. All from Barr sample 6972, Lizard Springs.
- 6 *Xestoleberis mauryae* van den Bold, n. sp.
a, right valve view of complete carapace. b, dorsal view of same. Kugler sample 2950, Soldado Rock.

PLATE 2

All figures $\times 50$.

- 1 *Cytherella* sp.
Right valve view of complete specimen. Barr sample 6972, Lizard Springs.
- 2 *Bairdia dolicha* van den Bold, n. sp.
a, right valve view of complete carapace. b, dorsal view of same. Cummings sample 35, Soldado Rock.
- 3 *Bairdia soldadensis* van den Bold, n. sp.
a, right valve view of complete specimen. b, dorsal view of same. Cummings sample 35, Soldado Rock.
- 4 *Bairdia* aff. *hondurasensis* van den Bold
a, right valve view of complete specimen. b, dorsal view of same. Cummings sample 35, Soldado Rock.

VAN DEN BOLD

- 5 *Bairdia cespedecensis* van den Bold
a, right valve view of complete specimen. b, dorsal view of same. Cummings sample 1048, Navet formation, San Fernando Bypass.
- 6 *Bairdia exoura* van den Bold, n. sp.
Right valve view of complete specimen. Cummings sample 1048, Navet formation, San Fernando Bypass.
- 7 *Bairdia* sp.
Right valve view of complete specimen. Grimsdale sample 31, Soldado Rock.
- 8 *Bairdia* sp.
Right valve view of complete specimen. Cummings sample 40, Soldado Rock.
- 9 *Bythocypris guppyi* van den Bold, n. sp.
Cummings sample 1048, Navet formation, San Fernando Bypass.
- 10 *Bythocypris* sp.
a, right valve view of complete carapace. b, dorsal view of same. Kugler sample 10832, Lizard Springs formation, Pointe-a-Pierre.
- 11 *Paracypris* aff. *limburgensis* van Veen
Right valve view of complete specimen. From 8556-8571 feet in well Rochard 1.
- 12 *Paracypris communis* van den Bold
a, right valve view of complete carapace. b, dorsal view of same. Cummings sample 35, Soldado Rock.

PLATE 3

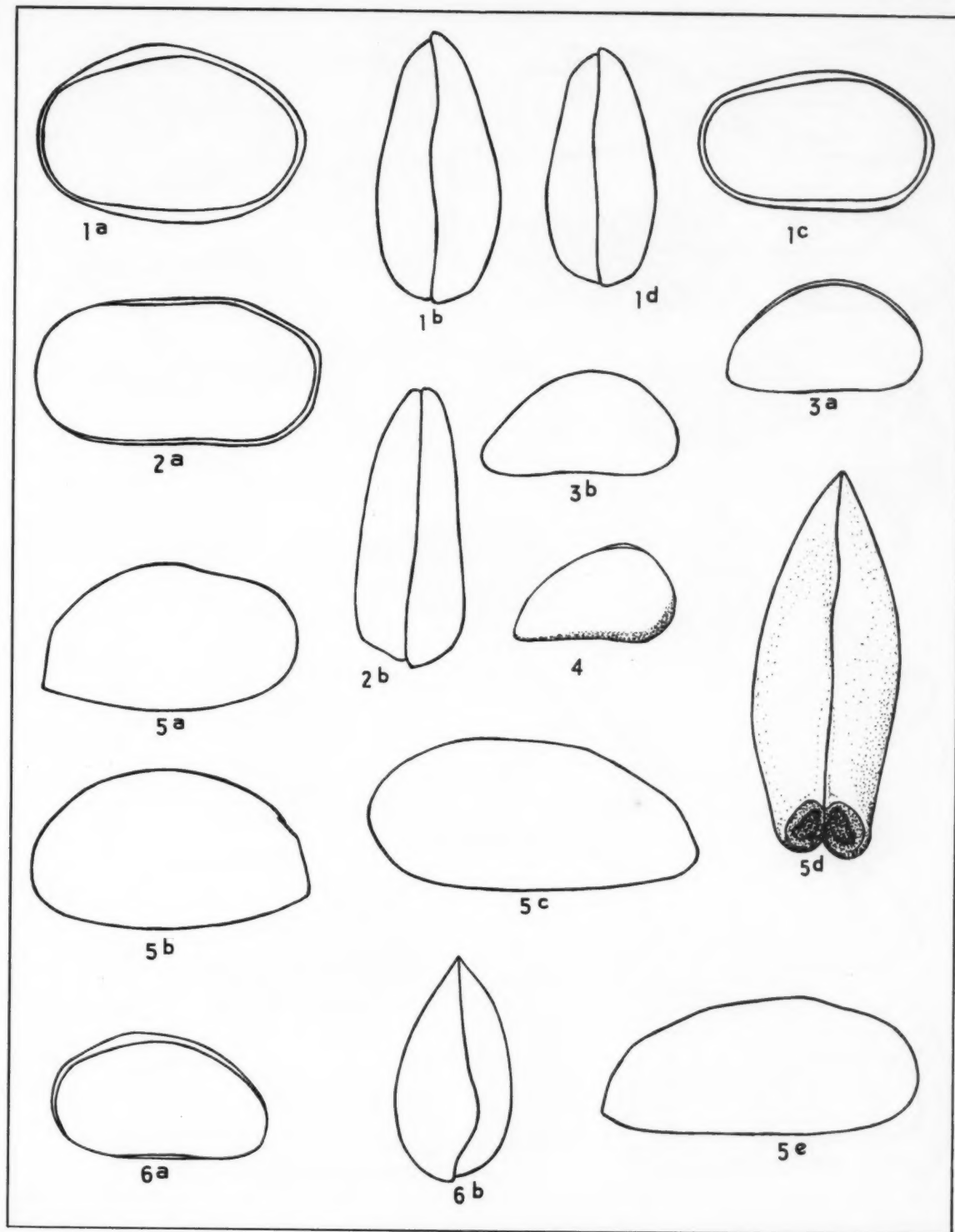
All figures $\times 50$.

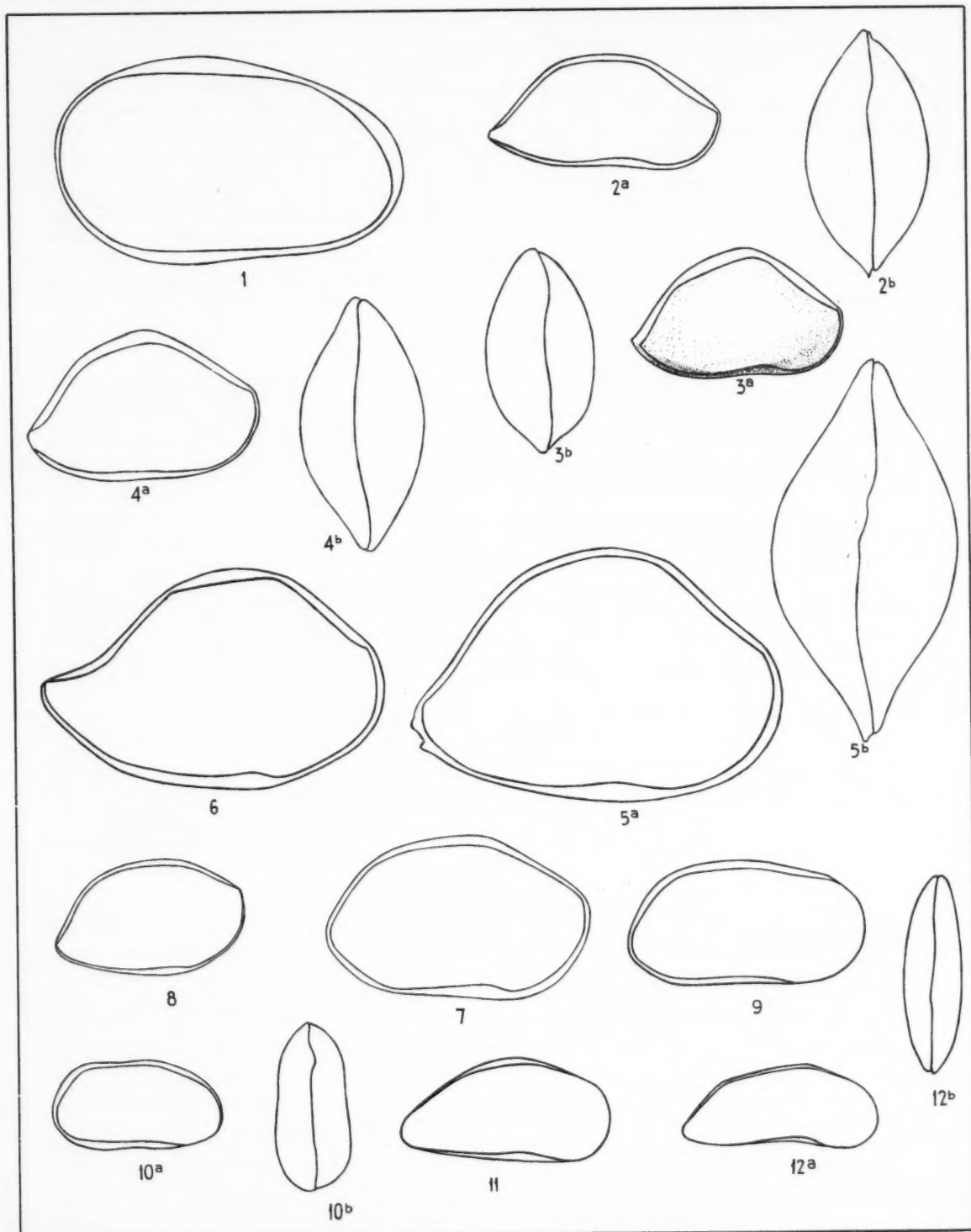
- 1 *Cythereis?* *trinidensis* van den Bold, n. sp.
a, exterior of left valve; Moore sample 995, upper Cipero, *Globorotalia fohsi* zone. b, dorsal view of complete specimen; Cummings sample 1047, Navet formation, San Fernando Bypass. c, interior of right valve; Favre sample 56, upper Cipero, *Globorotalia fohsi* zone. d, interior of same left valve as in figure 1a.
- 2 *Cythereis?* *sculptilis* Alexander
a, right valve view of complete specimen; Kugler sample 9415, Lizard Springs. b, interior of right valve; Barr sample 6972, Lizard Springs.
- 3 *Isocythereis?* aff. *fissicostis* Triebel
a, right valve view of complete specimen. b, interior of right valve. Both from Hawkins sample 1831, Lizard Springs.
- 4 *Trachyleberis?* *spinosissima* (Jones and Sherborn)
a, right valve view of complete carapace. b, dorsal view of same. Grimsdale sample 31, Soldado Rock.
- 5 *Trachyleberis?* sp.
a, right valve view of complete carapace. b, dorsal view of another specimen. Both from Kugler sample 9415, Lizard Springs.
- 6 *Hermanites collei* (Gooch)?
a, right valve view of complete specimen. b, dorsal view of same. Kugler sample 2951, Soldado Rock.
- 7 *Hermanites?* *grimsdalei* van den Bold, n. sp.
a, right valve view of complete specimen. b, dorsal view of same. Grimsdale sample 31, Soldado Rock.
- 8 *Brachycythere maerkyi* van den Bold, n. sp.
a, left valve view of complete carapace. b, dorsal view of same. Barr sample 6972, Lizard Springs.
- 9 *Puriana?* sp.
a, right valve view of complete carapace. b, dorsal view of same. Grimsdale sample 31, Soldado Rock.
- 10 *Cytheretta arrugia* van den Bold, n. sp.
a, right valve view of complete carapace. b, dorsal view of same. From 11,000-11,010 feet in well FC-98.
- 11 *Paracytheretta?* *maracensis* van den Bold, n. sp.
a, right valve view of complete carapace. b, dorsal view of same. From 11,020-11,033 feet in well FC-98.

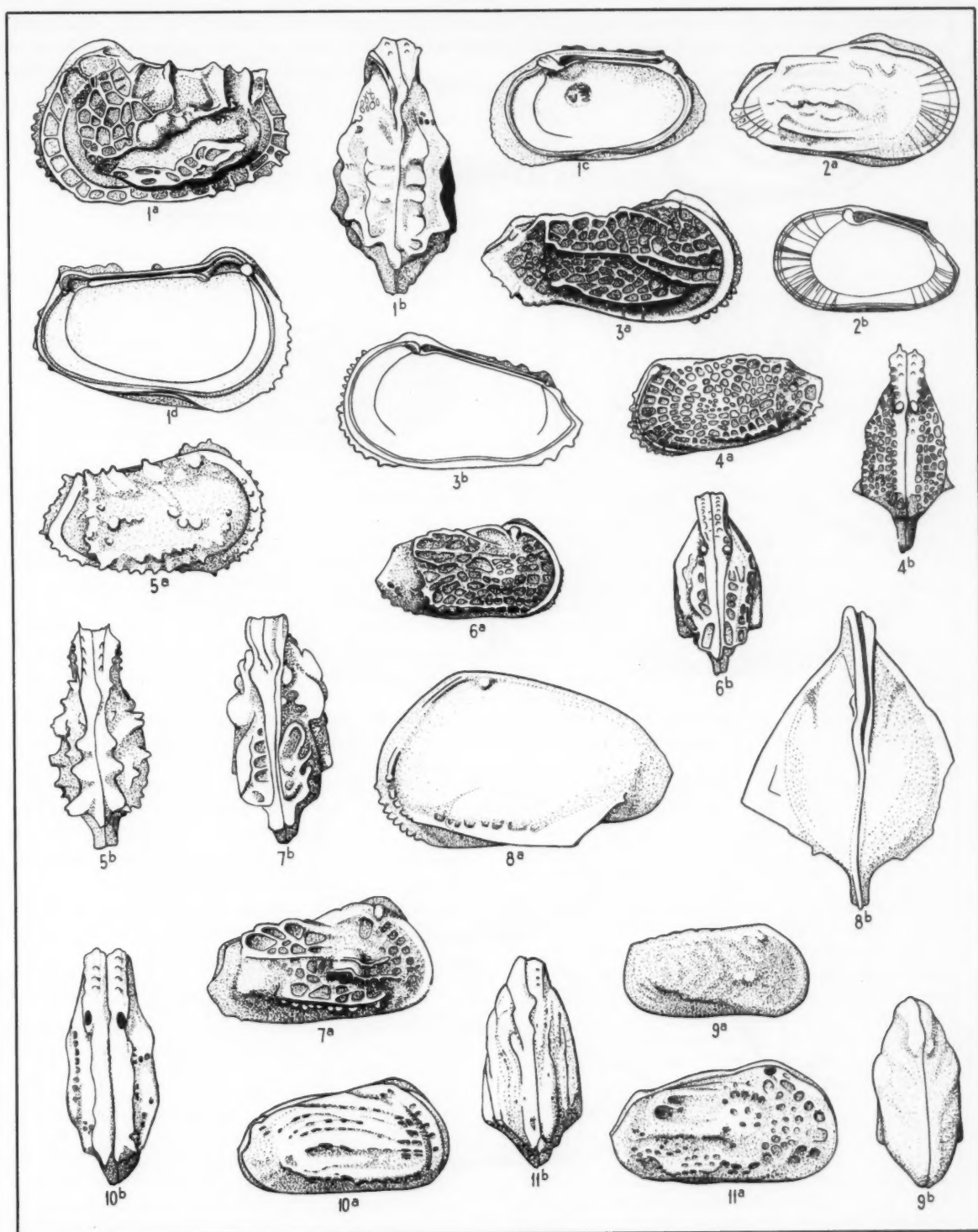
PLATE 4

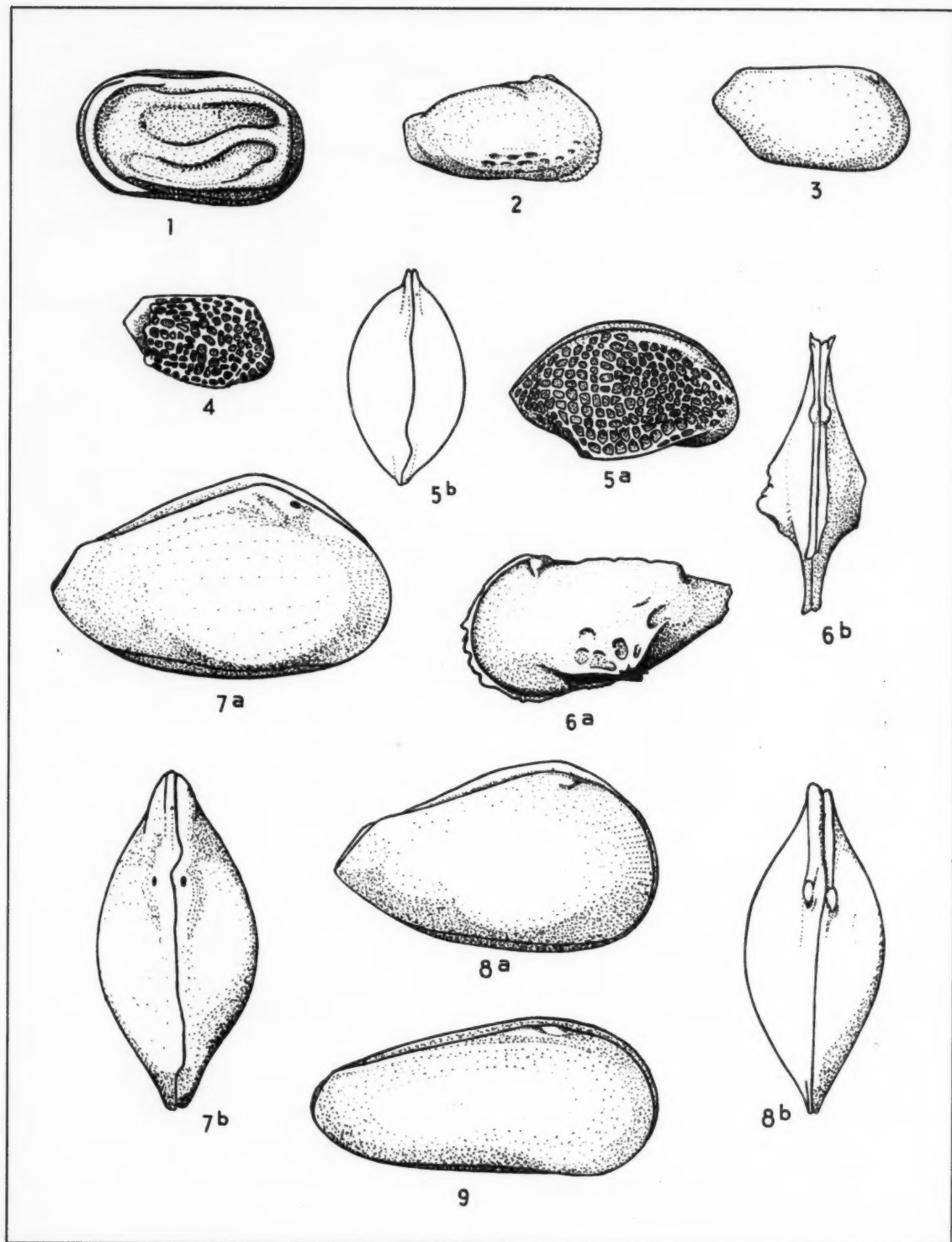
All figures $\times 80$.

- 1 *Cytherelloidea* sp.
Left valve view of complete specimen. Kugler sample 2950, Soldado Rock.
- 2 *Cytheromorpha* sp.
Right valve view of complete carapace. Cummings sample 35, Soldado Rock.
- 3 *Loxoconcha nuda* Alexander
Right valve view of complete specimen. Kugler sample 2950, Soldado Rock.
- 4 *Eucytherura decorata* Weingeist
Right valve view of complete carapace. Kugler sample 2950, Soldado Rock.
- 5 *Cytheropteron liogluma* Munsey
a, right valve view of complete specimen. b, dorsal view of same. From 11,000-11,010 feet in well FC-98.
- 6 *Pterygocythereis* sp.
a, left valve view of complete carapace. b, dorsal view of same. Kugler sample 2950, Soldado Rock.
- 7 *Brachycythere?* *kugleri* van den Bold, n. sp.
a, right valve view of complete specimen. b, dorsal view of same. From 11,020-11,033 feet in well FC-98.
- 8 *Brachycythere?* *kugleri soldadensis* van den Bold, n. subsp.
a, right valve view of complete specimen. b, dorsal view of same. Grimsdale sample 31, Soldado Rock.
- 9 *Brachycythere?* *kugleri* van den Bold var.
Right valve view of complete carapace. Grimsdale sample 31, Soldado Rock.









ABSTRACT: *A method of contact microradiography, which is useful in revealing the internal structure of whole foraminifera, is described. Microradiographs of a number of different foraminifera, which demonstrate the type of result that can be expected with this method, are reproduced in this paper.*

Microradiography applied to the study of foraminifera

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INTRODUCTION

The use of X rays in the study of structural phenomena is well known. Because of the short wavelength and the high penetrating power of X rays, radiography has proved to be a valuable method in morphology, whether the morphological units be sub-, micro-, or macroscopic. The tests of foraminifera, with their great variety of internal structures which are so important in taxonomic studies, are suitable subjects for radiographic study. The present practice of sectioning a test in order to determine the internal structure is time-consuming, and the specimen is inevitably destroyed. Other methods of studying test morphology, such as dissection techniques, with or without the aid of impregnating or supporting substances, also involve the destruction of the specimen.

The author is currently investigating X-ray methods and their application to foraminiferal problems. A report on the promising results obtained by a method of contact microradiography is given here.

METHOD

The term "microradiography" was introduced by Goby (1913), who described the apparatus he used, and included among his examples a small sample of foraminifera. Schmidt (1952), using X-ray diffraction equipment, reported radiographs of microfossils and noted the internal arrangement of the chambers of foraminiferal tests and the muscle-scar patterns of ostracodes. The present status of X-ray microscopy and contact microradiography has been reviewed recently by Nixon (1955). The same author outlined the development of the biological application of this

technique. Microradiography is used as a method of studying sections or whole objects normally not more than 1 mm. in thickness. Consequently, foraminifera that are of such a magnitude should be good subjects for study, although a certain measure of success has also been obtained with those of larger size.

Briefly, contact microradiography is the production of an X-ray image or radiograph by "soft" X rays, that is, X rays of relatively long wavelength. This X radiation is directed onto a photographic emulsion on which the object for study has been placed. The resultant X-ray image may then be examined with an optical microscope, or a photomicrograph can be obtained from it.

MATERIALS

Source of the X radiation

The X-ray tube used in this investigation (X-ray tube AEG-50-A, Machlett Laboratories, Inc., U.S.A.) is claimed by the manufacturers to be suitable for microradiography, historadiography, and radiography of small animals. The focal spot is 1.5 mm. square; the anode is of vacuum-cast copper with a tungsten target, and the cathode has a tungsten filament. This apparatus has a range of 0-55 kv, and is installed so that the radiation is directed vertically.

The photographic emulsion

"Kodak" Maximum Resolution Plates were used. These have an almost grainless emulsion, and, under specified conditions, a resolving power of 1000 lines

per mm. is claimed by the manufacturers. Photographic emulsions such as these, or the Lippmann type, are essential in order to obtain the necessary high magnification of the radiograph either during examination with the optical microscope or in the preparation of a photomicrograph. The sensitivity of an emulsion decreases with decrease in size of the constituent grains. Consequently, these maximum-resolution plates are slow-working and have a high exposure factor.

Mounting of the foraminifera

The ideal condition in contact microradiography is to have the specimen in direct contact with the photographic emulsion. With large foraminifera, such as *Astrorhiza* and *Cycloclypeus*, this is practicable. In the case of others, however, which are 1 mm. or less in diameter, there is great possibility of losing them under darkroom conditions. Furthermore, it is necessary to orient the specimens, an operation best carried out with optical and adhesive aids. The problem presented is to find a suitable mount for the foraminifera which can be prepared with the specimens attached prior to the darkroom procedures. The mounting material must be as transparent to X rays as possible and sufficiently strong to allow normal mounting operations. Cardboard, for example, is useless, as the constituent fibres give a relatively heavy shadow. A number of promising substances have been tried, among which are cleared X-ray film, cellophane, and Styrafoil (a product of B. X. Plastics, Ltd.). The mount or holder that has been used successfully is simply a thin piece of cardboard with a central cut-out panel. The mounting material is secured in this frame by cellulose tape.

A test holder was constructed with strips of cleared X-ray film, cellophane and Styrafoil, which, in addition, had an area that was uncovered and would therefore be exposed directly to the X radiation. This test holder was placed firmly on the photographic emulsion; the radiographic factors were 25 kv, 10 mA, at a height of 15 cm. for 15 minutes. The plate was developed, fixed and washed, and examined with an X-ray microphotometer. The readings here recorded are relative, not absolute, and are galvanometer deflection units. For the four parts of the plate that had similar treatment (the uncovered part of the plate; the strip covered with Styrafoil, 12.5 μ thick; the strip covered with cellophane; and the strip covered with cleared X-ray film), the galvanometer deflections were 14, 19.6, 24, and 48, respectively. Obviously, with this intensity of X radiation, Styrafoil gives the least

interference, and something of this sort is clearly preferable to the other two materials as a mount. With higher X-ray intensities, cellophane can be used with negligible interference. Styrafoil is an oriented film of polystyrene, which has been used previously by Barclay (1951) in his microarteriography technique. Gum tragacanth was used as an adhesive to keep the foraminifera in position, and this gum does not cause any visible interference.

PROCEDURE

The foraminifera are mounted with the aid of gum tragacanth on a Styrafoil or cellophane sheet, which is held taut by cellulose tape in the frame of a cardboard holder. This holder is then placed on top of the photographic plate, which is lying with the emulsion facing upward on top of a table. The holder is pressed close to the plate by means of lead-cloth sheeting. This is a normal accessory of an X-ray laboratory, and is radio-opaque. In addition to keeping the specimen frame flat and close to the emulsion, it also shields from radiation that portion of the plate not covered by specimens. In this way, one can make a number of different exposures on different parts of the same plate.

The direction of the radiation is set for vertical, and the next stage is to select the intensity of the radiation to be used. The intensity or quantity of X radiation is directly proportional to the current used; it varies as the square of the voltage and inversely as the square of the distance between the origin of the X rays and the object under examination (Schall, 1932). The height of the tube above the specimen affects not only the intensity but also the amount of geometrical blurring produced in the image. Nixon (1955) reports a blurring of 1 μ for a specimen 0.1 mm. thick at a distance of 10 cm. from a 1 mm. square source. This may not appear to be very significant, but with foraminifera that are 1 mm. or more in diameter, and a focal-spot size 1.5 mm. square, it is necessary to use a greater distance than, for example, 10 cm. in order to reduce the effect on the resolution.

This increase in the height of the tube will necessitate longer exposures because of the inverse square relationship between the distance and the intensity of radiation. This factor, in addition to the low sensitivity of the photographic emulsion being used, results in relatively long exposure times. Considering all these factors, a distance of 30 cm. was used on most occasions when photomicrographs were to be taken from the plates. To cut down exposure time for quick examination and for trials, the distance can be shortened by 50 per cent and the exposure

MICRORADIOGRAPHY OF FORAMINIFERA

time reduced by 75 per cent, as this combination will give the same intensity of radiation. The radiographic factors used are given in the plate explanations.

After exposure, the photographic plate is developed and washed in the way recommended by the manufacturer. Care must be taken not to overdevelop, otherwise the fine detail of the X-ray image will be lost. For this reason it is preferable to underdevelop. After fixation, the plate is thoroughly washed, and at this stage one of two procedures is possible. The first is to dry in a dust-free atmosphere, after which the plate is ready for microscopic examination. It is, however, extremely difficult to keep the plates clean and free from adherent dust particles. For this reason the author favours an alternative procedure which involves making a permanent preparation. After a thorough postfixation washing, the plate or parts of it cut to convenient size are dehydrated in a graded-strength series of ethyl alcohol, "cleared" in xylene, and mounted in a neutral balsam under a microscope cover glass. In this way, the emulsion with the X-ray images is protected and kept clean, and can be examined microscopically in the same way as any other microscopic or histological preparation.

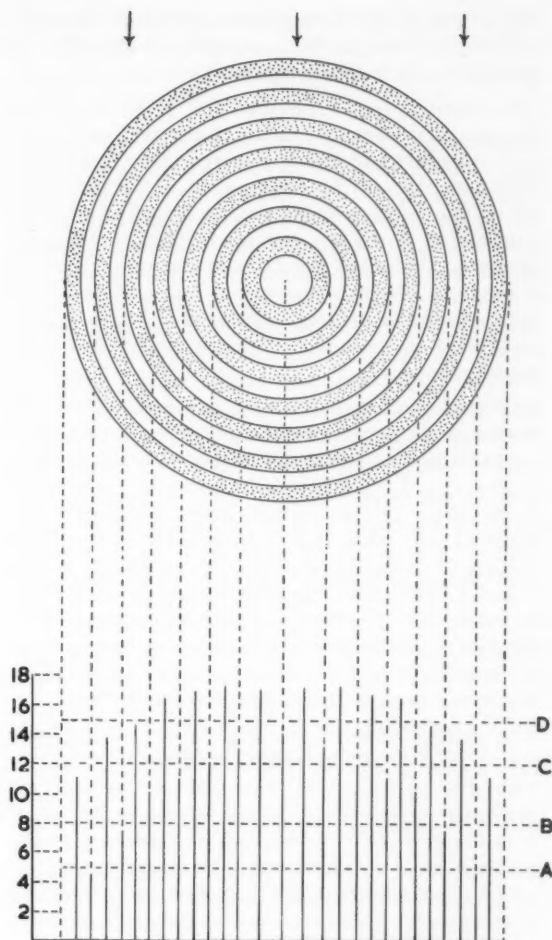
The method of photomicrography is the next stage in the procedure for the permanent recording or reproduction of the radiographs. This is now a well established photographic technique and is not discussed here.

OBSERVATIONS

The microradiographs illustrated in the accompanying plates are intended to show the possibilities of the method and to indicate the types of problems in which this technique may be useful. The author does not discuss fully all of the foraminifera that have been studied; this would result in an extensive review, which is not the purpose of this paper.

Test structure

In the case of *Rotalia* (pl. 1, fig. 1) and *Nonion* (pl. 1, fig. 3), with more intense radiation the outlines of the central chambers would be clearer, and the outermost wall and the septa would still produce an image. The shadows between the septa in *Rotalia* would no longer be present. In *Sphaeroidina* (pl. 1, fig. 2), the outer chamber wall is sufficiently opaque to produce an image with a radiation intensity which would result in a slightly clearer image of the early chambers. With this type of test, experience in interpretation is essential if misleading deductions are to be avoided.



TEXT-FIGURE 1

Diagram of a hypothetical foraminifer, with a line diagram to scale indicating the amount of calcareous material through which the X radiation must pass. Continuous black lines indicate total heights of columns of calcareous material in different parts of test; dotted lines included merely as guides. The X rays are coming from the direction of the arrows. For further explanation see the text.

The two microradiographs of *Peneroplis* (pl. 1, figs. 4-5) illustrate the process whereby it is possible to select certain structures for study by altering the radiographic factors. Used in this way, the process is tantamount to dissection by X rays. In figure 4 the central chambers are very clear, but at the expense of the thin calcareous ribs between the main septa, which have been retained in figure 5.

The stoloniferous passages are visible in figure 4, and with a stronger X-ray intensity it should be possible to show these even more clearly.

The central part of *Elphidium* (pl. 1, fig. 6) is very opaque, and to reveal its structure one would have to be prepared to lose the image of the outermost wall and parts of the outer septa and retral processes. The good-contrast microradiograph of *Spiroloculina* (pl. 1, fig. 7) was made from a damaged specimen. Although the damage was unintentional, it serves to illustrate, firstly, the value of retaining such specimens in a collection, and, secondly, the quality of the results one might expect from dissected material.

In plate 2 an attempt has been made to demonstrate the amount of internal structure that can be seen in microradiographs of *Pyrgo* (figs. 1-3) and *Quinqueloculina* (fig. 8). The forms shown in figures 2 and 8 have given better-contrast microradiographs because of their small size and relatively thin walls as compared with those of the specimens in figures 1 and 3. The latter required a much more intense radiation for effective penetration, and it will be difficult to obtain better complete microradiographs for specimens of their size and construction. They border on the theoretical limits of this method.

The central chamber arrangement in *Cycloclypeus* (pl. 2, fig. 5) appears to be satisfactorily recorded. The dust particles on this microradiograph are practically unavoidable if the photographic plate is exposed to the air. Although on this occasion the particles have not destroyed the value of the radiograph, they might readily have done so. This is one of the problems that have led to the preparation of the plates as permanent balsam mounts.

The early enclosed chambers of *Orbulina* have been revealed (pl. 2, fig. 6), and with more intense radiation a little more of these chambers would be visible in the X-ray image. The absence of any internal chambers in another specimen (pl. 2, fig. 4) indicates that the early chambers may have been resorbed.

Such foraminifera as *Reophax*, *Rhabdammina*, and *Astrorhiza* (plate 3) are large enough to be placed next to the emulsion. The usefulness of the radiograph will depend on the size and composition of the particles of foreign material in the tests of these forms. For example, *Astrorhiza* (pl. 3, fig. 8) is composed of relatively large opaque sand grains, and there is no sign of a chamber cavity.

Wall structure

This method of contact microradiography of whole foraminifera cannot be expected to give vivid and

well-defined images of wall structure. For detailed studies of this nature, other procedures, which may or may not incorporate X rays, are required. Preferably, these methods should be applied to sections of the subject. Nevertheless, microradiographs of whole foraminifera will reflect the type of wall structure.

The radial arrangement of the wall of *Rotalia* is visible in plate 1, figure 1, and is clearly seen in plate 3, figure 2. The white shadow between the septa in both of these microradiographs is an image of wall material, and is not an artifact caused by the grain of the photographic materials. The imperforate nature of the miliolid type of wall is seen in *Spiroloculina* (pl. 1, fig. 7), *Pyrgo* (pl. 2, figs. 1-3) and *Quinqueloculina* (pl. 2, fig. 8), and the small and large perforations of the wall of *Orbulina* (pl. 2, figs. 4, 6) are clearly visible. In plate 3, figure 1, the image is a clear indication of the minute grains of which the wall of *Endothyra* is composed. In the case of *Keramosphaera* (pl. 3, fig. 4), where only a part of the test was radiographed, the tubule openings in the wall are shown. A number of details seen in the microradiographs which have not been discussed in the text will be noted by the reader. This is inevitable without resort to a detailed account of each type.

DISCUSSION

At present, it is the characters of the test, rather than those of the soft parts, which form the basis of foraminiferal taxonomy. External characters, such as shape and size and those concerning the aperture, are easily observed and can be recorded by photographic methods. The internal characters, such as chamber arrangement and the microscopic wall structure, require alternative techniques. One example is the use of polarized light in the examination of thin sections. With this procedure interesting results have been obtained, which have clarified some of the problems of wall structure (Wood, 1949). In the case of chamber arrangement, however, it is still common practice to dissect the test and to record the results in a reconstructed drawing. These procedures are of undoubted value, but nevertheless they are time-consuming and destructive.

With a radiographic technique, most specimens can be studied without destroying them. This possibility is of particular value in the re-examination of described collections and in the examination of type specimens. In either case the dissection of the specimens is highly undesirable. Furthermore, when large numbers of specimens are to be studied, microradiography is by far the quicker and easier method of examination.

MICRORADIOGRAPHY OF FORAMINIFERA

Caution must be used in interpreting the X-ray image. Until the worker is experienced in interpretation, erroneous conclusions can be drawn. To overcome this factor, it is helpful and comparatively easy to make stereoscopic pairs of the object.

It was noted earlier that the method of contact radiography is actually of value only with objects 1 mm. or less in thickness. However, a useful radiograph was obtained from a *Pyrgo* which was approximately 2 mm. in diameter. With uniserial or planispiral foraminifera, which present little structural complexity, there is practically no limitation to the value of the method. In the case of such forms as *Pyrgo* and *Quinqueloculina*, however, there is a limit beyond which the radiation will give no better radiograph.

For example, we may consider a hypothetical seven-chambered calcareous test (text-fig. 1). This may have many inherent defects, but will suit the purpose of this discussion. The diagram is drawn to scale and is a guide to the height of the column of calcareous material through which the X rays would have to pass to produce complete penetration. If radiographic factors were employed that would result in an X-ray intensity sufficient to penetrate a column approximately 5 units thick (indicated by line A), then the outermost chamber wall would appear on the radiograph as a white image quite distinct from the black area representing the last chamber. There would be poor contrast in the remainder of the interior, and the contrast would decrease toward the centre. If the intensity of the X radiation were increased so that it would penetrate a column approximately 8 units thick (indicated by line B), the two outer chamber walls would each give a white image contrasting with the black area of the last and penultimate chambers. Again, the rest of the interior would have poorer contrast. If an intensity were now used which would penetrate a column 12 units thick (indicated by line C), good black-white contrast would be expected between the walls of chambers 3, 4, 5, and 6 and their respective chambers. No image, however, would be recorded of the outermost chamber, and the radiograph would be incomplete. If black-white contrast were required between the primordial chamber and its wall, then an intensity of radiation would be needed which would pene-

trate a column approximately 15 units thick (indicated by line D). This would penetrate chambers 5, 6, and 7 completely, and no image of these chambers would be formed.

This is the type of limitation which prevents the production of an ideal black-white-contrast radiograph of certain foraminifera. For practical purposes, however, even with the large *Pyrgo*, the contrast between the chamber walls and the chambers themselves is sufficient for interpretation when the intensity of X rays used is capable of penetrating a column approximately 11 units thick. This would also give a faint image of the wall of chamber 7 in the hypothetical form. Other types of foraminifera, such as *Endothyra* and *Alveolina*, present difficulties in the way of good radiography because of their microstructure or chamber arrangement.

In addition to their value in revealing internal chamber arrangement, microradiographs indicate a variety of wall structures. In this type of inquiry, much can be learned without resorting to sectioning.

The author wishes to thank P. E. Purves for his willingness to discuss X-ray problems, and also M. G. Sawyers for his cooperation in the preparation of the photographs. Appreciation is also expressed to Dr. W. H. Parker, Dr. F. C. Fraser, and Dr. R. H. Cummings for reading the manuscript.

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EXPLANATION OF PLATES

In plates 1-4, the radiographic factors that were used are given for each figure. The distance given represents the focus-to-film distance; the time-value refers to the period of exposure to radiation. Further explanations of the micro-radiographs are given in the text.

PLATE 1

- | | |
|--|---|
| 1 <i>Rotalia</i> sp. 25 kv, 10 mA, 30 cm., 60 minutes;
× ca. 120. | 5 <i>Peneroplis</i> sp. 20 kv, 10 mA, 30 cm., 60 minutes;
× ca. 55. |
| 2 <i>Sphaeroidina</i> sp. 20 kv, 10 mA, 15 cm., 15 minutes;
× ca. 75. | 6 <i>Elphidium</i> sp. 20 kv, 10 mA, 15 cm., 15 minutes;
× ca. 60. |
| 3 <i>Nonion</i> sp. 20 kv, 10 mA, 15 cm., 15 minutes;
× ca. 65. | 7 <i>Spiroloculina</i> sp. 20 kv, 10 mA, 15 cm., 15 minutes;
× ca. 55. |
| 4 <i>Peneroplis</i> sp. 25 kv, 10 mA, 30 cm., 60 minutes;
× ca. 40. | 8 <i>Orbitolites</i> sp. 20 kv, 10 mA, 15 cm., 15 minutes;
× ca. 35. |

PLATE 2

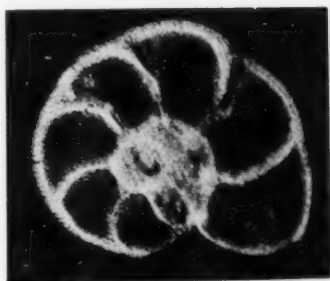
- | | |
|--|---|
| 1 <i>Pyrgo</i> sp. 45 kv, 14 mA, 30 cm., 60 minutes; × ca. 20. | 5 <i>Cycloclypeus</i> sp. 45 kv, 10 mA, 30 cm., 60 minutes;
× ca. 80. |
| 2 <i>Pyrgo</i> sp. 20 kv, 10 mA, 30 cm., 60 minutes; × ca. 120. | 6 <i>Orbulina</i> sp. 25 kv, 10 mA, 30 cm., 60 minutes;
× ca. 40. |
| 3 <i>Pyrgo</i> sp. 45 kv, 14 mA, 30 cm., 60 minutes; × ca. 20. | 7 " <i>Polytrema</i> " sp. 50 kv, 10 mA, 30 cm., 60 minutes;
× ca. 12. |
| 4 <i>Orbulina</i> sp. 25 kv, 10 mA, 30 cm., 60 minutes;
× ca. 60. | 8 <i>Quinqueloculina</i> sp. 20 kv, 10 mA, 30 cm., 60 minutes;
× ca. 85. |

PLATE 3

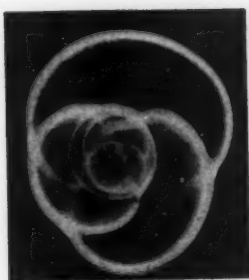
- | | |
|---|--|
| 1 <i>Endothyra</i> sp. 45 kv, 12 mA, 30 cm., 60 minutes;
× ca. 55. | 5 <i>Rhabdammina</i> sp. 25 kv, 10 mA, 30 cm., 60 minutes;
× ca. 4. |
| 2 <i>Rotalia</i> sp. 20 kv, 10 mA, 30 cm., 60 minutes;
× ca. 300. | 6 <i>Reophax</i> sp. 30 kv, 10 mA, 30 cm., 60 minutes;
× ca. 16. |
| 3 <i>Alveolina</i> sp. 40 kv, 10 mA, 30 cm., 60 minutes;
× ca. 30. | 7 <i>Astrorhiza</i> sp. 35 kv, 10 mA, 30 cm., 60 minutes;
× ca. 16. |
| 4 <i>Keramosphaera</i> sp. 40 kv, 10 mA, 30 cm., 60 minutes;
× ca. 16. | 8 <i>Astrorhiza</i> sp. 40 kv, 10 mA, 30 cm., 60 minutes;
× ca. 10. |

PLATE 4

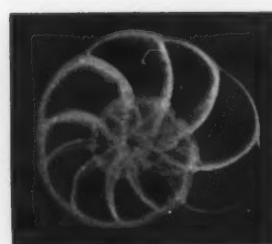
Pyrgo sp. 20 kv, 10 mA, 30 cm., 60 minutes; × ca. 475. This photograph was taken from the same microradiograph as that used in plate 2, figure 2, and illustrates the high magnifications permitted by this method.



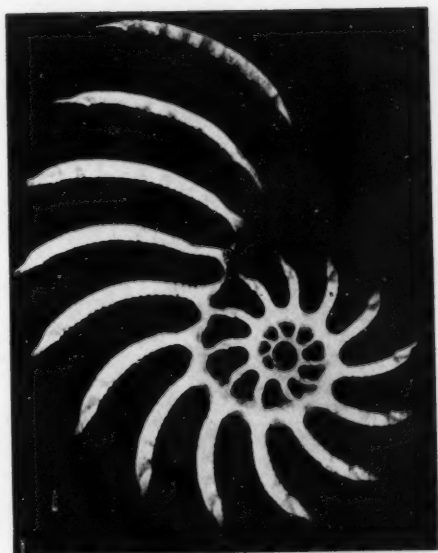
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2



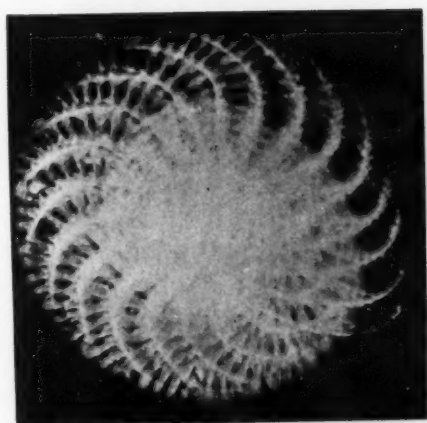
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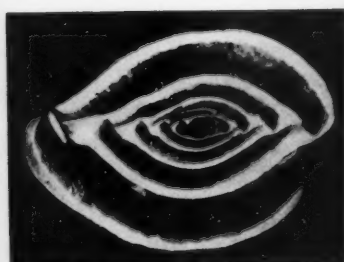
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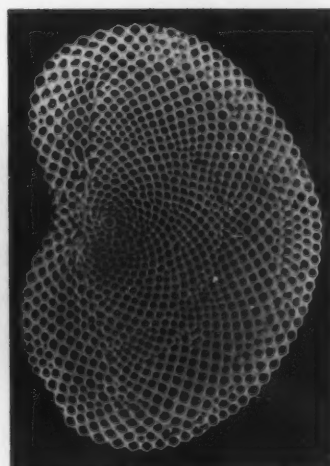
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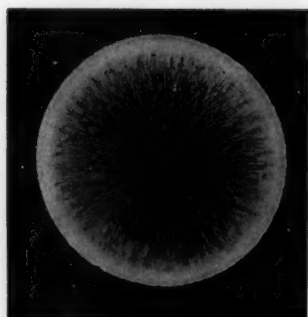
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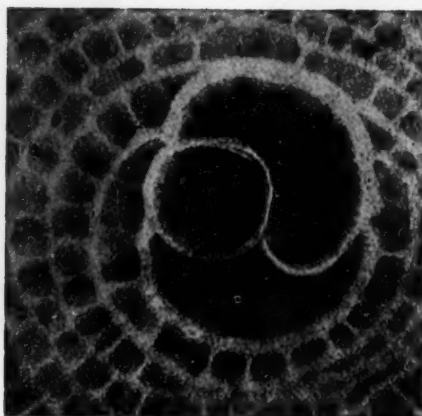
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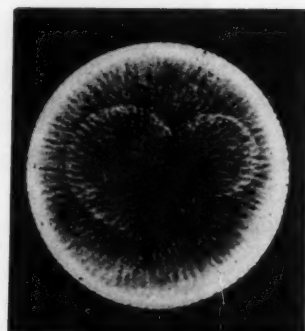
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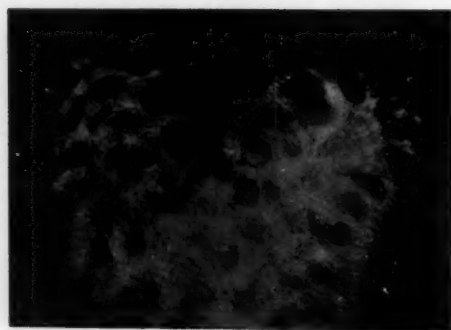
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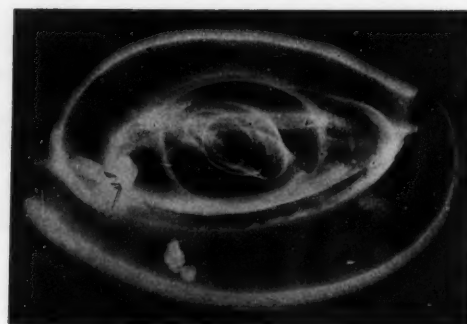
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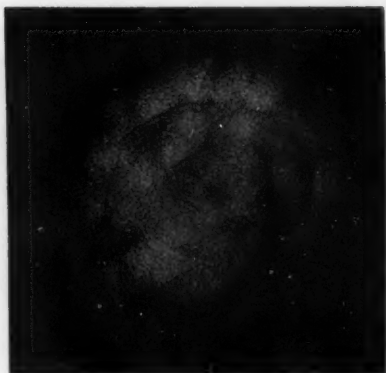


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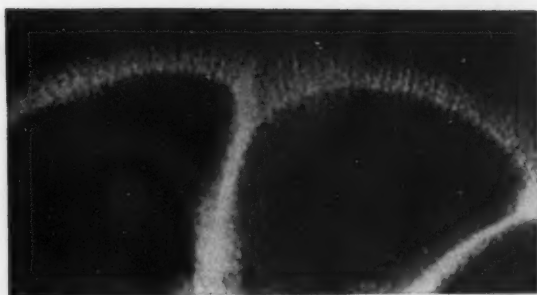


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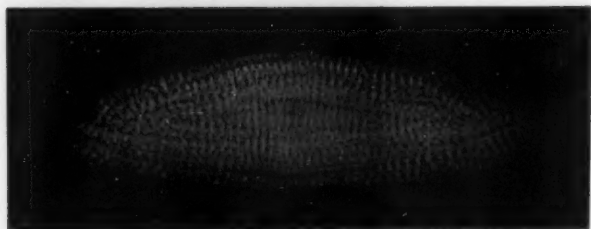
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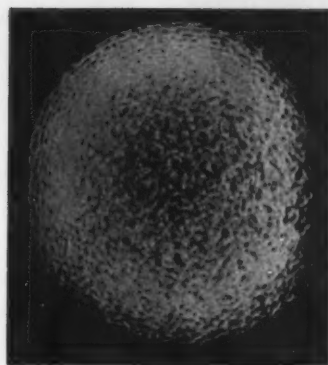
2



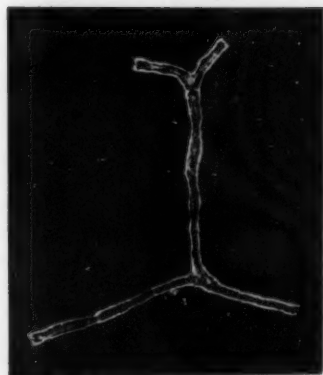
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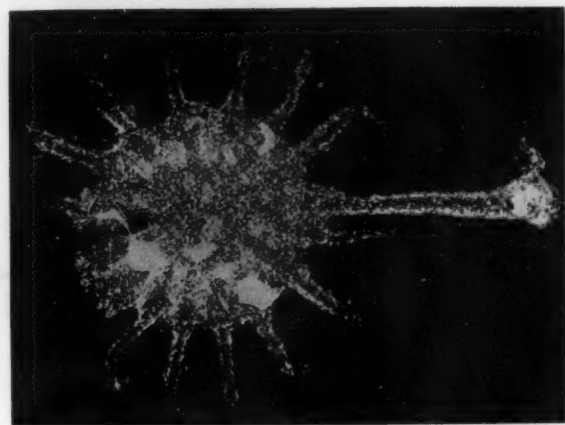
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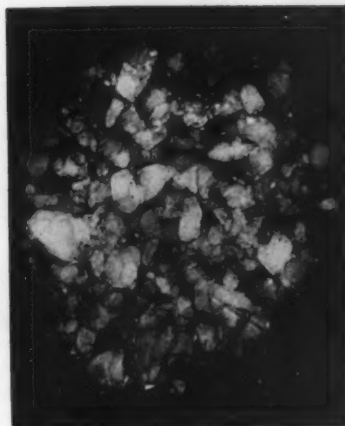
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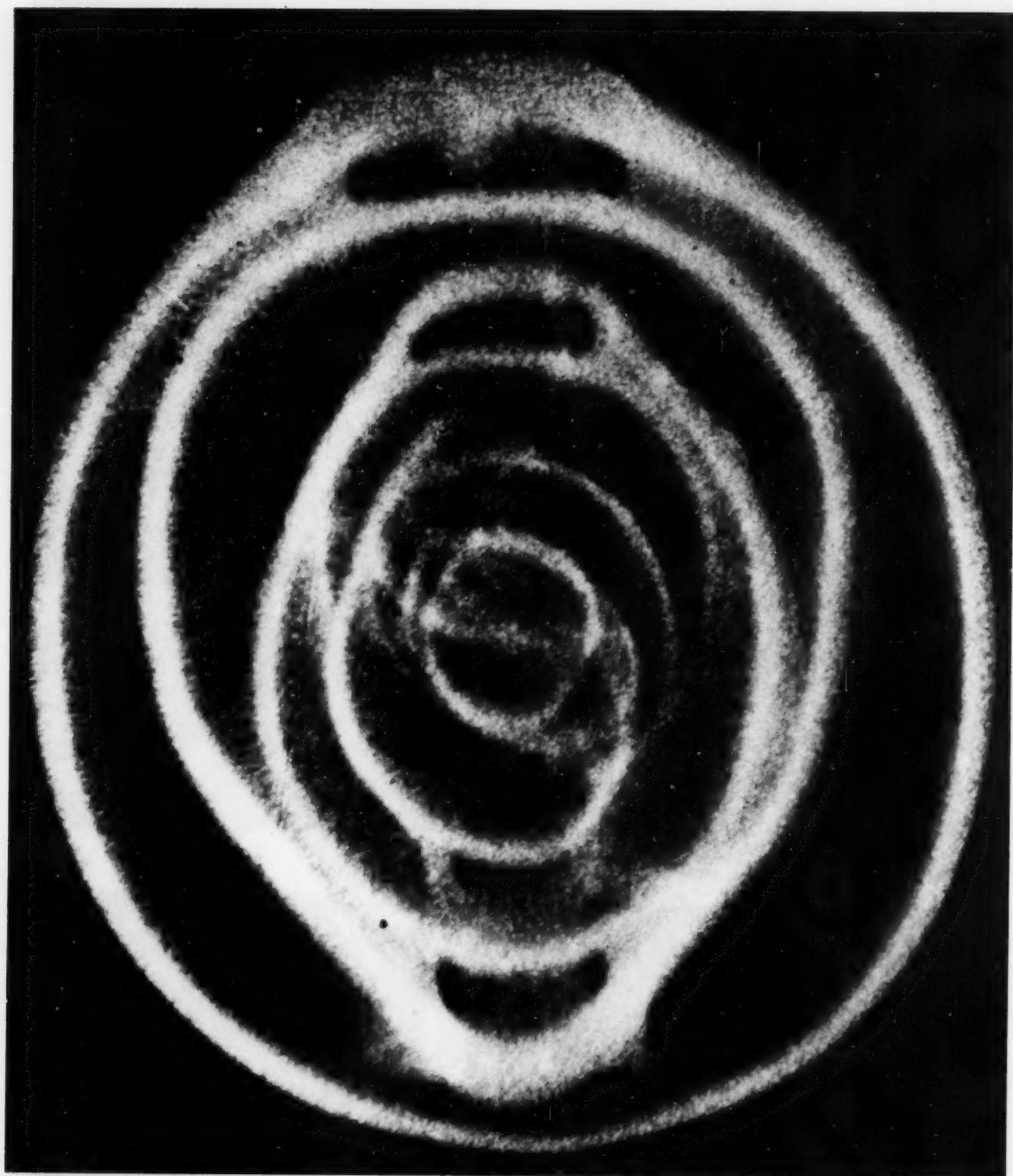


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ABSTRACT: Six rotaliid foraminifera from Upper Cretaceous reef deposits of the Caribbean region are discussed. One species, *Sulcoperculina angulata* Brown and Bronnimann, is new. *Siderolites vanbelleni* (van den Bold) and *Kathina jamaicensis* (Cushman and Jarvis), originally described from strata thought to be of Eocene age, are regarded as Upper Cretaceous fossils. *Siderolites skourensis* (Pfender), *Stomatorbina binkhorsti* (Reuss), and *Eponides hemisphaericus* (Reuss), which are known from the type Maestrichtian in Holland, are recorded from Cuba.

Some Upper Cretaceous rotaliids from the Caribbean region

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Cuban Gulf Oil Company
Havana

Rotaliid foraminifera are common in the Upper Cretaceous reef-complexes of the Caribbean region. Henson (1950), in an informative study, has indicated the distribution of foraminifera in the various environments represented by Cretaceous and Tertiary reef-complexes in the Middle East. Many of the rotaliids of the Caribbean region are representative of similar depositional environments, corresponding to those recognized by Henson. The forms discussed in this paper include certain species of the genera *Sulcoperculina* Thalmann, *Kathina* Smout, *Siderolites* Lamarck, *Rotalia* Lamarck, *Eponides* Montfort, and *Stomatorbina* Dorreen. In general, but with many exceptions, they are characteristic of the back-reef environment of the reef-complex, where they are commonly associated with such thick-walled orbitoids as *Orbitoides* d'Orbigny, *Monolepidorbis* Astre, *Omphalocyclus* Bronn, and *Torreina* D. K. Palmer, and also cuneolinids, peneroplids, alveolinids, and miliolids. They are less commonly found in reef-talus, where they may be associated with thin-walled orbitoids that characterize fore-reef deposits, such as *Sulcorbitoides* Bronnimann, *Pseudorbitoides* H. Douvillé, *Rhabdorbitoides* Bronnimann, *Historbitoides* Bronnimann, *Vaughanina* D. K. Palmer, *Lepidorbitoides* A. Silvestri, and *Asterorbis* Vaughan and Cole. They are rarely found associated with planktonic foraminifera, e.g., globotruncanids and gumbelinids, in sediments deposited off-shore beyond the influence of reef environments.

The purpose of this paper is not only to clarify the nomenclature of some of these forms, but also to point out their paleoecologic and stratigraphic relationships in the Upper Cretaceous reef deposits of the Caribbean region.

All figured specimens are deposited in the collections of the Cuban Gulf Oil Company, Havana.

SYSTEMATIC PALEONTOLOGY

Genus *SULCOPERCULINA* Thalmann, 1939

Sulcoperculina angulata Brown and Bronnimann,
new species

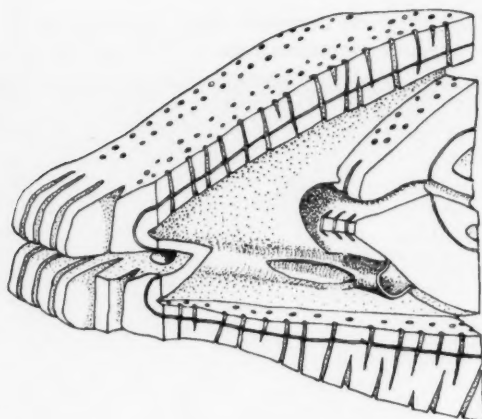
Text-figures 2-3

Sulcoperculina angulata Brown and Bronnimann, MS., in BRONNIMANN, 1956, Cushman Found. Foram. Res., Contr., vol. 7, p. 64 (*nomen nudum*).

Description: This species has been observed only in thin sections. The axial section of the test is roughly elongate-hexagonal in outline, the maximum diameter being that from sulcus to sulcus of the final whorl. The massive umbos are axially flattened, and distinct angulations are formed at the edges of the flat umbos. Heavy pillars exist; occasionally they are at the edges of the umbos. The marginal sulcus is deep and connected by intra-septal canals with the asymmetric spiral canal on the ventral side of the test. The basal aperture is asymmetric and extends from the dorsal (upper) rim of the sulcus, across the sulcus, to the ventral side of the test above the spiral canal. The final whorl has seventeen or eighteen chambers. The following measurements, in microns, are taken from centered axial sections of six specimens:

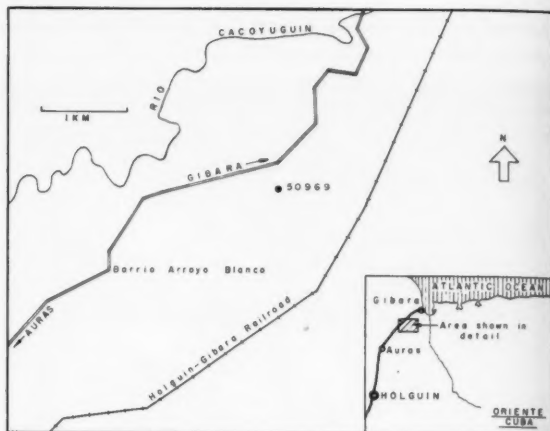
Specimen number	1	2	3	4	5	6
Diameter of test	460	580	705	720	770	905
Thickness of test	295	450	385	410	475	640
Ratio of diameter to thickness	1.56	1.29	1.83	1.76	1.62	1.41

Remarks: *Sulcoperculina angulata*, n. sp., differs from all other *Sulcoperculinas* in its elongate-hexagonal outline in axial section, and in possessing flattened umbos. It is



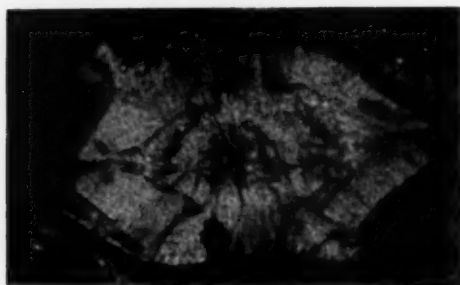
TEXT-FIGURE 1

Schematic reconstruction of *Sulcoperculina*, showing the internal structure. The spiral canal of the outer whorl lies just below (ventral to) the sulcus of the inner whorl. At the septum it bends sharply and extends within the septum as the radial canal. At the periphery of the outer whorl, it opens into the sulcus between the two rows of radial plates. Not to scale.

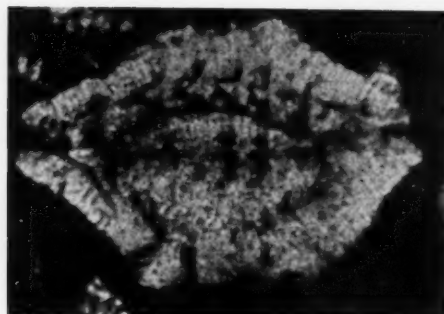


TEXT-FIGURE 4

Map showing Kozary station 50969, the type locality of *Sulcoperculina angulata* Brown and Bronnimann, n. sp. This is also the type locality of *Historbitoides kozaryi* Bronnimann.



2



3

TEXT-FIGURES 2-3

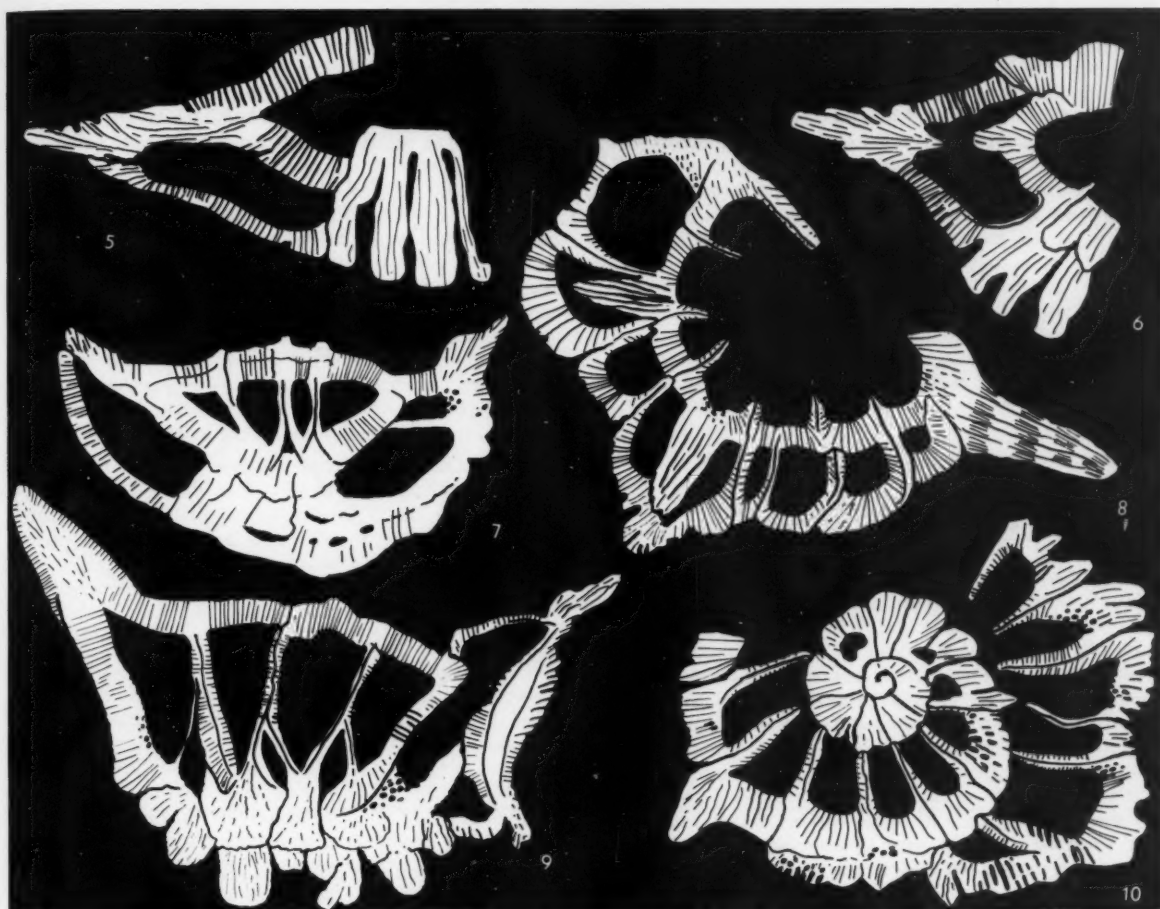
Axial (vertical) sections of *Sulcoperculina angulata* Brown and Bronnimann, n. sp.: 2, holotype; 3, paratype. Maestrichtian (Upper Cretaceous), Kozary station 50969. $\times 86$.

similar in shape to *Nummulites scotlandica* de Cizancourt, from the Eocene Scotland beds of Barbados, B.W.I. It is most closely related to and associated with the massive *Sulcoperculina globosa* de Cizancourt, which was originally described from the Maestrichtian of San Sebastián, State of Guárico, Venezuela. We agree with Renz (1955, p. 55) that *Sulcoperculina obesa* de Cizancourt should be regarded as a synonym of *Sulcoperculina globosa*.

Smout (1955, p. 202), in his reclassification of rotaliid foraminifera, states: "The Miscellaneidae have strong radial canals in all genera excepting *Sulcoperculina*, which is a very unusual form and a misfit in any family." He later (ibid., p. 206, footnote 4) apparently contradicts this statement by stating that *Miscellanea* does not have

radial canals. Whether *Miscellanea* possesses radial canals or not, we must disagree with Smout concerning *Sulcoperculina*. We have observed intraseptal radial canals and spiral canals in all known species of *Sulcoperculina*. Although Palmer confuses the dorsal and ventral sides, she gives (1934, p. 244) an excellent description of the canal system in her *Camerina? dickersoni*, the genotype of *Sulcoperculina*. A schematic reconstruction of *Sulcoperculina* showing its canal system is presented in text-figure 1.

Sulcoperculina is generally found in the fore-reef environment of the reef-complex. However, where it occurs in large numbers with few other foraminifera, it may be indicative of a back-reef environment.



TEXT-FIGURES 5-10

Vertical and horizontal sections of *Siderolites vanbelleni* (van den Bold).

Occurrence: *Sulcoperculina angulata* occurs in the reef-talus fragmental limestone of the Ramonín member of the José formation (Maestrichtian), which is exposed at Kozary station 50969, Gibara area, Oriente Province, Cuba (see text-fig. 4). The type locality of *Sulcoperculina angulata* is described by M. T. Kozary (oral communication) as follows:

"Station 50969 lies a few meters north of a well-preserved old Spanish watchtower located along an east-trending rise about 380 meters south of the Holguín-Gibara highway at km. 24, within the Argüelles farm, Barrio Arroyo Blanco, Municipio Gibara. The exposure is a 3-meter wide, 17-meter long, vertical-dipping, east-striking tectonic sliver of limestone within a predominantly ultramafic terrane."

Sulcoperculina angulata is associated with *Sulcoperculina globosa* de Cizancourt, *Sulcoperculina* cf. *S. vermunti* (Thiaden), *Vaughanina cubensis* D. K. Palmer, *Historbitoides kozaryi* Bronnimann (type), *Orbitoides* sp., prisms of

Inoceramus, other mollusk fragments, and remains of echinoderms and algae. The age of the assemblage is Maestrichtian. The holotype of *Sulcoperculina angulata* is the axial section illustrated in text-figure 2.

Genus *SIDEROLITES* Lamarck, 1801*Siderolites vanbelleni* (van den Bold)

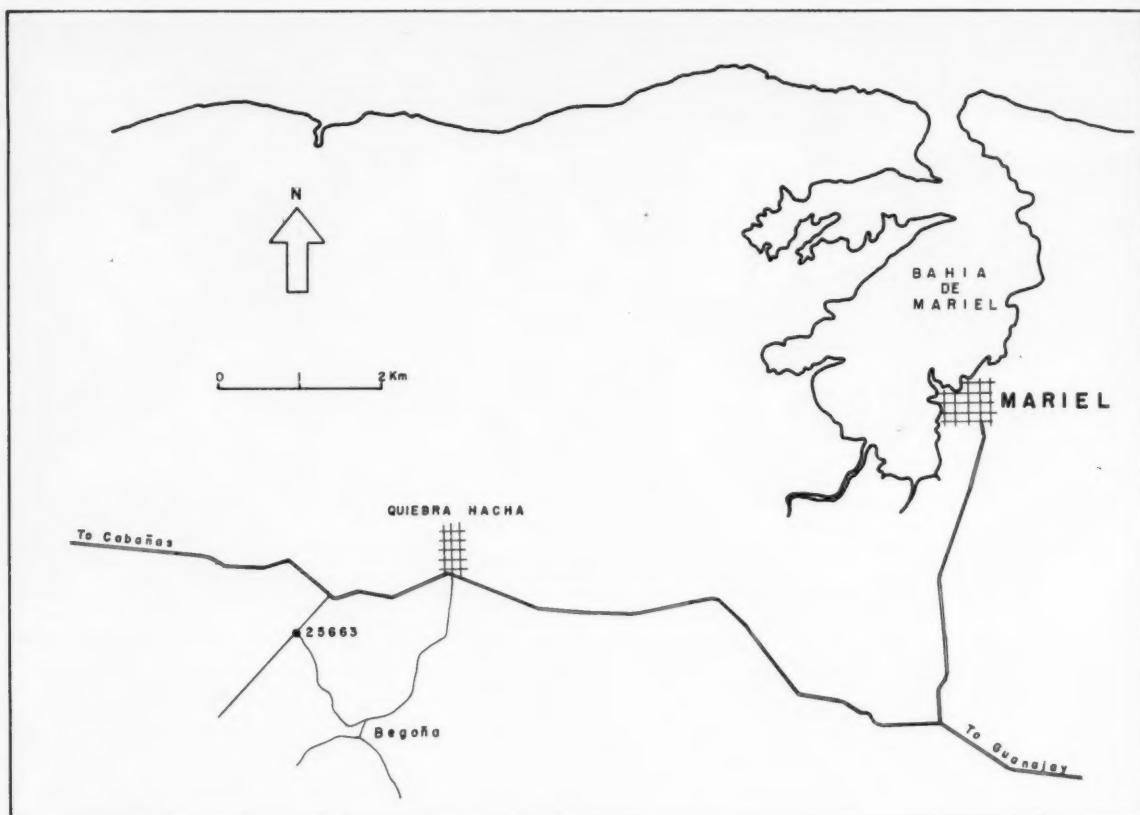
Plate 1, figures 4-6; text-figures 5-10

Rotalia aff. *trochidiformis* (Lamarck). - KEIJZER, 1945, Utrecht, Univ., Geogr. Geol. Meded., Physiogr.-Geol. Reeks, ser. 2, no. 6, p. 203, pl. 11, figs. 1-2, 4; text-fig. 32.

Cibicides? *vanbelleni* VAN DEN BOLD, 1946, *Contribution to the study of Ostracoda*, p. 125, pl. 18, fig. 8a-c.

Eponides vanbelleni (van den Bold). - CUSHMAN, 1951 (part), U. S. Geol. Survey, Prof. Paper no. 232, p. 53, pl. 20, figs. 11-13 (not pl. 23, fig. 10a-c).

Emended description: The rather large lenticular to plano-convex test is coiled in a low trochoid spire composed of three whorls. Its dorsal side is commonly flat, and its



TEXT-FIGURE 11

Map showing Truitt station 25663, where *Siderolites vanbelleni* (van den Bold) has been found.

ventral side broadly rounded. The trochoid spire can be recognized only in thin sections because supplementary perforate shell material covers and obscures the preceding part of the test with the addition of each chamber. At the center, on both sides of the test, the surface of the supplementary shell material appears to be broken up into rather coarse pustules and tubercles. On the ventral side, toward the periphery, each chamber is marked by fine parallel costellae, which are radial or which run obliquely from the anterior edge of the chamber ventrally toward the posterior edge of the chamber. The costellae become discontinuous and are broken up into pustules and tubercles toward the center. Chambers of the first whorl increase rapidly and regularly in size as added. Chambers of the second whorl increase gradually and regularly in size as added. At the outer edge of a few chambers of the second whorl, and also of the last whorl in some specimens, a short to long, conspicuous, longitudinally striate spine projects upward (dorsally) at a rather steep angle. These spines have pointed extremities. In thin section they have a feather-like appearance. The fourteen to seventeen chambers of the last whorl increase gradually and

irregularly in size as added. The size of the chambers in this whorl does not increase regularly, because of the obstruction of the peripheral spines of the chambers of the preceding whorl. If the spine is short enough, a chamber can be formed around it, but if the spine is long, a regular-sized chamber cannot be accommodated, and a relatively narrow, radially elongate chamber is formed next to it before regular-sized chambers can again be formed. The umbilical plug is split into strong pillars. The aperture has not been observed in this species.

Remarks: Smout (1955, pp. 205, 206) regards *Calcarina* d'Orbigny as a junior synonym of *Siderolites* Lamarck, and he thereby extends the range of *Siderolites* from Cretaceous to Recent. We agree with him that these forms cannot be separated generically on a morphologic basis. However, we believe that they are homeomorphs with different phylogenies, and that representatives of these forms will not be found in every stage from Maestrichtian to Recent. *Siderolites* has usually been regarded as a planispiral genus and *Calcarina* as a trochospiral genus. However, Schijfsma (1946, p. 26,

pl. 8, fig. 2; pl. 10, fig. 4) has demonstrated that some specimens of *Siderolites calcitrapoides* Lamarck, the genotype of *Siderolites*, are trochospiral. *Siderolites vanbelleni* is actually morphologically more similar to the Recent *Calcarina spengleri* (Gmelin); however, it is referred to *Siderolites*, not simply because the name *Siderolites* has priority over the name *Calcarina*, but because it is phylogenetically much more closely related to *Siderolites calcitrapoides*. *Siderolites vanbelleni* differs from *Calcarina spengleri* in having fewer chambers in the last whorl and fewer peripheral spines. The extremities of the spines of *Siderolites vanbelleni* are pointed, whereas those of *Calcarina spengleri* are branching or club-shaped. Most specimens of *Siderolites calcitrapoides* are planispiral, but all specimens of *Siderolites vanbelleni* are trochospiral. The spines of *Siderolites calcitrapoides* begin on the chambers of the initial whorl, whereas those of *Siderolites vanbelleni* begin on the chambers of the second whorl.

Siderolites vanbelleni and *Siderolites calcitrapoides* are end-forms that became extinct at the end of Maestrichtian time. All transitions (text-figs. 5–10, 12–20) can be found from the trochospiral form *Rotalia tuberculifera* Reuss through *Siderolites skourensis* (Pfender) to *Siderolites vanbelleni*. *Siderolites calcitrapoides* seems to be an off-shoot in which trochospiral forms are gradually replaced by planispiral forms.

The paleoecology of *Siderolites vanbelleni* and related species was probably very similar to the ecology of *Calcarina spengleri*. Cushman, Todd, and Post (1954, pp. 363, 364), in their study of the Recent foraminifera of the Marshall Islands, found *Calcarina spengleri* "on the reef flat in a fresh unworn condition with the shell wall white and the spines more or less complete. . . . This species occurs even more abundantly in a layer of velvety algae on the bare reef flat, particularly on the outer edge of the flat." Cloud (1952, p. 2144), who also reported that *Calcarinas* are characteristic of a reef-flat environment, noted: "Worn *Calcarina*, however, are at many places extremely abundant in the deposits of beaches and atoll islands and locally common in lagoon deposits."

Occurrence: *Siderolites vanbelleni* has been found in hard, white fragmental limestone of late Maestrichtian age in Oriente and Pinar del Río Provinces, Cuba. Keijzer (1945, pp. 158, 203), who called this species "*Rotalia* aff. *trochidiformis* Lamarck," recorded it from strata of "Danomontian" age, without convincing evidence. Truitt, station 25663 (see text-figure 11) is an exposure of weathered reef-talus fragmental limestone 500 meters south of a point 16.4 km. northwest of Guanajay on the road to Bahía Honda, near Begoña, Pinar del Río Province, Cuba. At this locality, *Siderolites vanbelleni* is found with *Vaughanina cubensis* D. K. Palmer, *Orbitoides* sp., and *Sulcoperculina* spp. At other localities it is usually associated with *Siderolites skourensis* (Pfender), *Stomatorbina binkhorsti* (Reuss), cuneolinids, alveolinids, and miliolids.

Van den Bold (1946, p. 125), who referred this species doubtfully to *Cibicides*, noted it from several localities in Guatemala and British Honduras. He did not indicate

the locality from which his only figured specimen, the holotype, was obtained. Furthermore, he did not state why he assigned a Lower Eocene age to the species. Cushman (1951, p. 53) recorded this species from the so-called Paleocene Madrugá formation "under highway bridge on Central San Antonio, Madrugá, Habana Province, Cuba. . . ." Our samples from this locality contain many Upper Cretaceous and Tertiary foraminifera. The Cretaceous forms, *Siderolites vanbelleni* among them, are obviously redeposited.

Siderolites skourensis (Pfender)

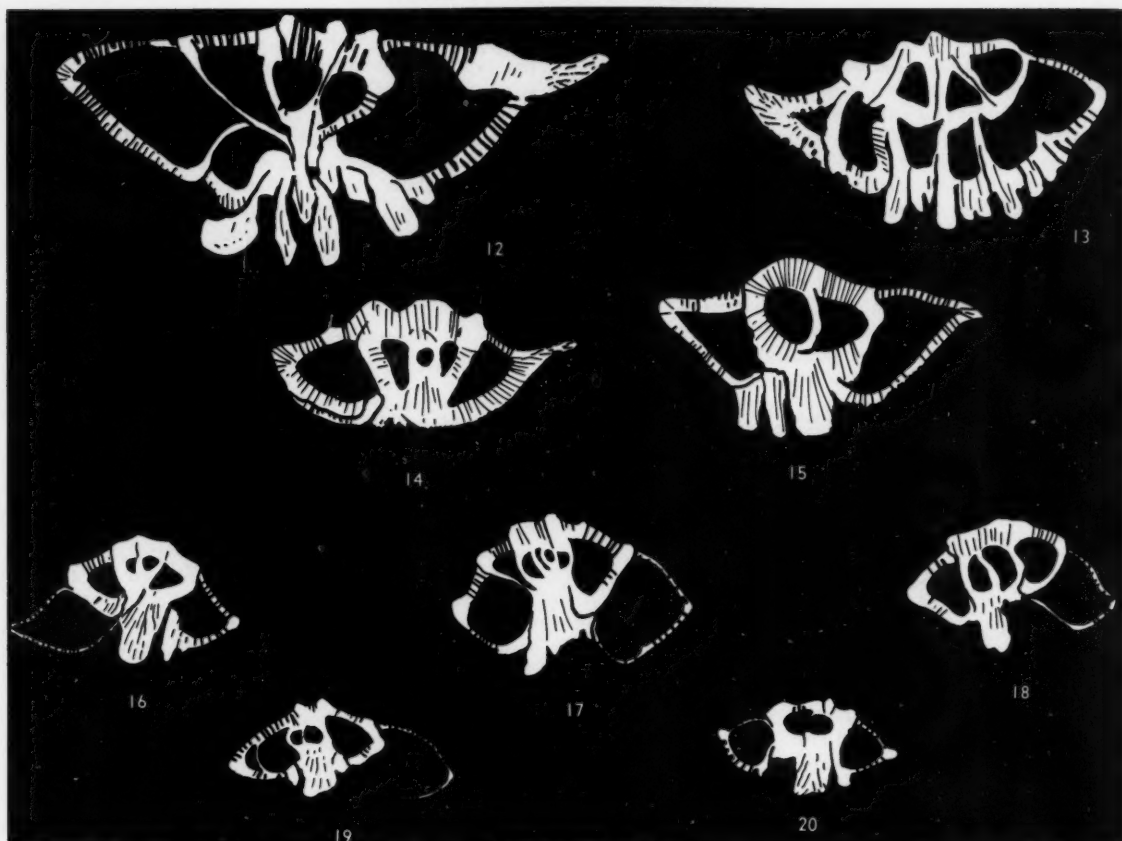
Plate 1, figures 1–3; text-figures 12–20

Rotalia skourensis PFENDER, 1938, in MORET, MOROCCO, Service des Mines, Notes et Mém., no. 49 (Mém. Pal., no. 11), p. 61, text-figs. 8–9.

Remarks: *Rotalia skourensis* Pfender is here treated as a primitive species of *Siderolites* because it exhibits peripheral spines similar to those of *Siderolites vanbelleni*. These spines can be seen in the thin sections of some of the thirty-three specimens originally figured by Pfender (1938, text-figs. 8–9). The small forms with weak spines that are usually referred to *Rotalia tuberculifera* Reuss, such as those figured by Hofker (1949, text-fig. 14A–O; 1951, text-figs. 15–18) and by Visser (1950, pl. 10, fig. 10; not fig. 9), are tentatively regarded as *Siderolites skourensis* (Pfender). Reuss (1862) neither described nor figured spines on *Rotalia tuberculifera*. However, there is a gradational series in the evolution of forms without spines, represented by *Rotalia tuberculifera* and *Rotalia primitiva* Cushman and Bermudez, to those forms with incipient spines, represented by *Siderolites skourensis*. *Siderolites vanbelleni* evolved from *Siderolites skourensis* by becoming larger and flatter on the dorsal side, and by adding peripheral spines earlier in the ontogeny. *Siderolites calcitrapoides* Lamarck is an off-shoot from this lineage. It evolved from *Siderolites skourensis* or an ancestor of *Siderolites skourensis* by becoming larger, tending to become planispiral, and adding peripheral spines still earlier in the ontogeny.

Siderolites vanbelleni has peripheral spines projecting upward (dorsally) from the chambers of the last two whorls. This upward (dorsal) projection of a spine of a chamber of the last whorl may be seen in some specimens of *Siderolites skourensis*, as shown in the axial (vertical) section of the form figured by Hofker (1949, p. 27, text-fig. 14H) as "*Nonion tuberculifera* (Reuss)." The parallel costellae that mark the ventral side of the chambers of *Siderolites vanbelleni* may also be seen in *Siderolites skourensis* as shown by Hofker (1951, p. 15, text-fig. 16b) in forms he called "*Parrella tuberculifera* (Reuss)."

Hofker (1949, p. 26; 1951, p. 16; 1954, p. 51) referred *Rotalia tuberculifera* first to *Nonion* Montfort, then to *Parrella* Finlay, and later to *Pararotalia* Y. LeCalvez. He may have even intended it to be the genotype of his *Gavelinonion*, as it is interpreted by Bermudez (1952,



TEXT-FIGURES 12-20

Vertical sections of *Siderolites skourensis* (Pfender).

p. 150) and by Thalmann (1953, p. 876). However, Hofker (1951, p. 17) merely mentions a new genus *Gavelinonion*, but does not describe it nor indicate a genotype for it. At the same time (ibid., pp. 16, 17), he refers *Rotalia tuberculifera* to Parrella, an unavailable synonym of *Osangularia Brotzen*, rather than to *Gavelinonion*. After disentangling this nomenclature, one must conclude that *Gavelinonion* is a *nomen nudum*.

Occurrence: *Siderolites skourensis* (Pfender) was originally described by Pfender (1938, p. 62) from so-called Maestrichtian-Danian beds in the southern foothills of the Atlas Mountains, French Morocco. The Danian part of this age assignment is probably not correct. Thalmann (1947, pp. 309, 310) reported this species from western Ecuador in the lowermost Guayaquil formation, just below strata that contain *Siphogenerinoides clarki* Cushman and Campbell, of Maestrichtian age. According to Visser (1950, pp. 303, 307), *Rotalia tuberculifera* (which probably includes *Siderolites skourensis*) and *Siderolites calcitrapoides* are the most common foraminifera in the type Maestrichtian. Similar or identical forms are found in the Dordonian of southern France.

In Cuba, *Siderolites skourensis* has been found in back-reef limestones, associated with *Siderolites vanbelleni*, *Stomatobina binkhorsti* (Reuss), cuneolinids, alveolinids, and miliolids. The figured specimen (pl. 1, figs. 1-3) is from Truitt station 25663 (text-fig. 11).

Genus EPONIDES Montfort, 1808

Eponides hemisphaericus (Reuss)

Text-figures 21-25

Rotalia hemisphaerica REUSS, 1862, K. Akad. Wiss. Wien, Sitzber., vol. 44, pt. 1, p. 314, pl. 2, fig. 5a-c.

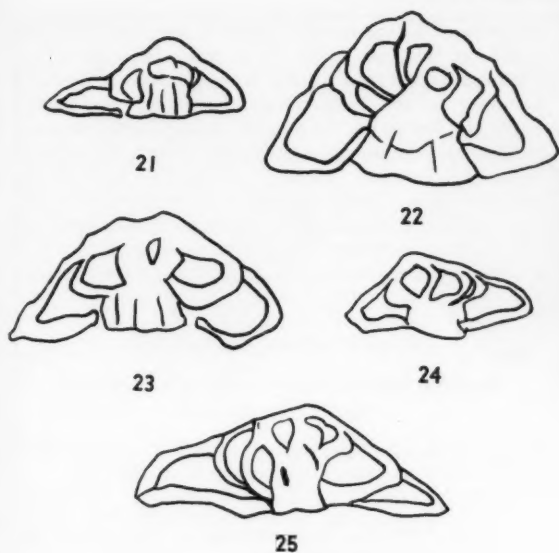
Cibicides involuta (Reuss). - HOFKER, 1949 (part), Inst. Roy. Sci. Nat. Belgique, Mém., no. 112, p. 21, text-fig. 12H, J, K, R (only).

Eponides hemisphaerica (Reuss). - VISSER, 1950, Leidse Geol. Meded., vol. 16, p. 272, pl. 6, fig. 1a-c.

Alabamina cretacea HOFKER, 1951, Natuurh. Gen. Limburg, Publ., vol. 4, p. 12, text-fig. 14a-f.

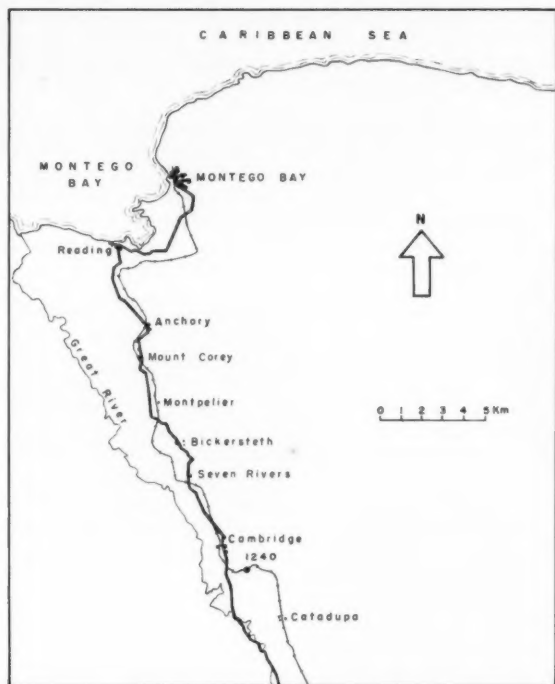
Remarks: We have observed this form only in thin sections. *Alabamina cretacea* Hofker probably can be included within the range of variation of *Eponides hemi-*

UPPER CRETACEOUS ROTALIIDS



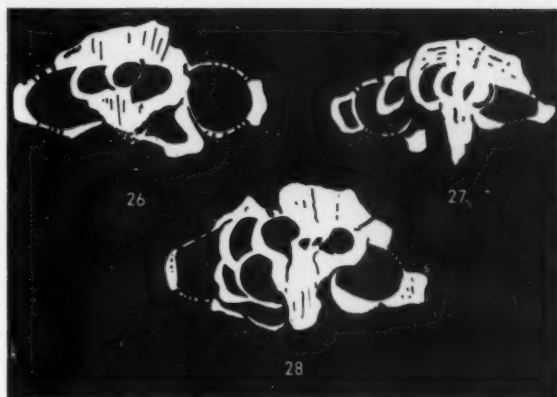
TEXT-FIGURES 21-25

Vertical sections of *Eponides hemisphaericus* (Reuss), from Truitt station 20610.



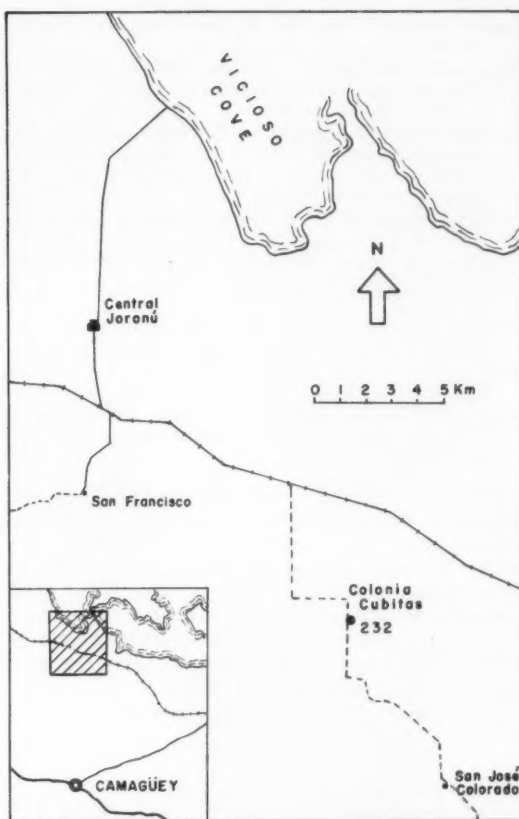
TEXT-FIGURE 30

Map showing Kozary station 1240, the type locality of *Kathina jamaicensis* (Cushman and Jarvis).



TEXT-FIGURES 26-28

Vertical sections of *Stomatorbina binkhorsti* (Reuss), from Bronnimann station 232.



TEXT-FIGURE 29

Map of Bronnimann station 232, the locality from which *Stomatorbina binkhorsti* (Reuss) is figured.

sphaericus (Reuss). In the genus *Alabama* Toulmin, the interiomarginal aperture lies below (ventral to) the dorsal wall, which extends beyond the indented septal face. Hofker's illustrations (1951, text-fig. 14b-c) show that the aperture of his *Alabama cretacea* is above (dorsal to) the indentation.

Occurrence: Reuss (1862, p. 314, pl. 2, fig. 5a-c) originally described this species from the type Maestrichtian. Visser (1950, p. 273) found it only in the upper Maestrichtian (Md). In Cuba, *Eponides hemisphaericus* has been found in back-reef limestones of Maestrichtian age, associated with cuneolinids, alveolinids, and miliolids. The figured specimens are from hard gray limestones, 4.6 km. southwest of Remedios, Camagüey Province, Cuba (Truitt station 20610).

Genus STOMATORBINA Dorreen, 1948

Stomatorbina binkhorsti (Reuss)

Text-figures 26-28

Rosalina binkhorsti REUSS, 1862, K. Akad. Wiss. Wien, Sitzber., vol. 44, pt. 1, p. 317, pl. 2, fig. 3a-c.

Discorbina binkhorsti (Reuss). - EGGER, 1900, K. Bayer. Akad. Wiss. München, Math.-Physik. Cl., Abh., vol. 21, pt. 1, p. 164, pl. 18, figs. 28-30.

Pulvinulina binkhorsti (Reuss). - HOFKER, 1927, Natuurh. Maandblad, vol. 16, no. 9, p. 126, text-figs. 4-11.

Conorbina binkhorsti (Reuss). - BROTZEN, 1936, Sver. Geol. Unders., ser. C, no. 396, p. 145.

Discorbis binkhorsti (Reuss). - VISSER, 1937, Natuurh. Maandblad, vol. 26, no. 8, p. 96. - BROTZEN, 1940, Sver. Geol. Unders., ser. C, no. 435, p. 32. - SCHIJESMA, 1946, Netherlands, Geol. Stichting, Meded., ser. C, pt. 5, no. 7, p. 82, text-fig. 4a-c.

Gavelinella binkhorsti (Reuss). - VISSER, 1950, Leidse Geol. Meded., vol. 16, p. 265, pl. 5, fig. 6a-c; pl. 10, fig. 12.

Discopulvinulina binkhorsti (Reuss). - HOFKER, 1951, Natuurh. Gen. Limburg, Publ., vol. 4, p. 20, text-figs. 22a-e, 23a-c.

Stomatorbina binkhorsti (Reuss). - BERMUDEZ, 1952, Venezuela, Minist. Minas e Hidrocarb., Bol. Geol., vol. 2, no. 4, pp. 33, 36.

Remarks: We have observed this species only in thin sections. It is easily recognized by its conspicuous thick, limbate, imperforate peripheral band. Bermudez (1952, pp. 33, 36) has noted that this species should be referred to the genus *Stomatorbina* Dorreen. The Eocene form *Lamarckina torrei* Cushman and Bermudez, the genotype of *Stomatorbina*, is very similar to *Stomatorbina binkhorsti*, but it is thicker and has more limbate, imperforate shell material on its sutures and periphery.

Occurrence: This species was originally described by Reuss (1862, p. 317, pl. 2, fig. 3a-c) from the type Maestrichtian. It is common in the Kunrade chalk of southern Limburg in the Netherlands. In Cuba, *Stomatorbina binkhorsti* (Reuss) has been found in back-reef limestones of Maestrichtian age, associated with *Siderolites vanbelleni*, *Siderolites skourensis* (Pfender), miliolids, cuneolinids, and alveolinids. The figured specimens are from Bronniman station 232, an exposure of gray-brown limestone just south of Colonia Cubitas on the road to San José Colorado, Camagüey Province, Cuba (see text-figure 29).

Genus KATHINA Smout, 1954

Kathina jamaicensis (Cushman and Jarvis)

Plate 1, figures 7-10

Eponides jamaicensis CUSHMAN AND JARVIS, 1931, Cushman Lab. Foram. Res., Contr., vol. 7, p. 77, pl. 10, fig. 4a-c.

Lockhartia bermudezi COLE, 1942, Jour. Pal., vol. 16, p. 641, pl. 92, figs. 1-5. - APPLIN AND JORDAN, 1950, ibid., vol. 24, p. 476, pl. 66, figs. 8-10. - BERMUDEZ, 1952, Venezuela, Minist. Minas e Hidrocarb., Bol. Geol., vol. 2, no. 4, p. 176, pl. 12, figs. 7-9.

Kathina bermudezi (Cole). - SMOUT, 1954, Lower Tertiary foraminifera of the Qatar Peninsula, p. 61, pl. 7, figs. 9-13.

Remarks: *Lockhartia bermudezi* Cole is a junior synonym of *Eponides jamaicensis* Cushman and Jarvis. This species is neither an *Eponides* nor a *Lockhartia*, and should be assigned to the genus *Kathina*, as noted by Smout (1954, pp. 49, 61).

Occurrence: Cushman and Jarvis (1931, pp. 75, 77, 78) originally described *Kathina jamaicensis* as a Middle Eocene fossil. They did not record any fossils associated with it, and there seems to be no clear reason for this age assignment. Perhaps they were following Hill (1899), who failed to discriminate between Upper Cretaceous and Middle Eocene strata in Jamaica.

The type locality of this species, as given by Cushman and Jarvis (1931, pp. 77, 78), is an exposure at the "96th mile, 11th telegraph post, on the Jamaica Government Railway, near Catadupa Station, Jamaica, B.W.I." According to M. T. Kozary (oral communication), this same locality is 1 km. east of the railway crossing of the Cambridge-Marchmont road in St. James Parish (Kozary station 1240) (see text-figure 30). He has kindly furnished us samples of this material. The three lowest samples contain *Kathina jamaicensis* in association with alveolinids, *Meandropsina* sp., rare *Sul-*

PLATE 1

1- 3 *Siderolites skourensis* (Pfender)

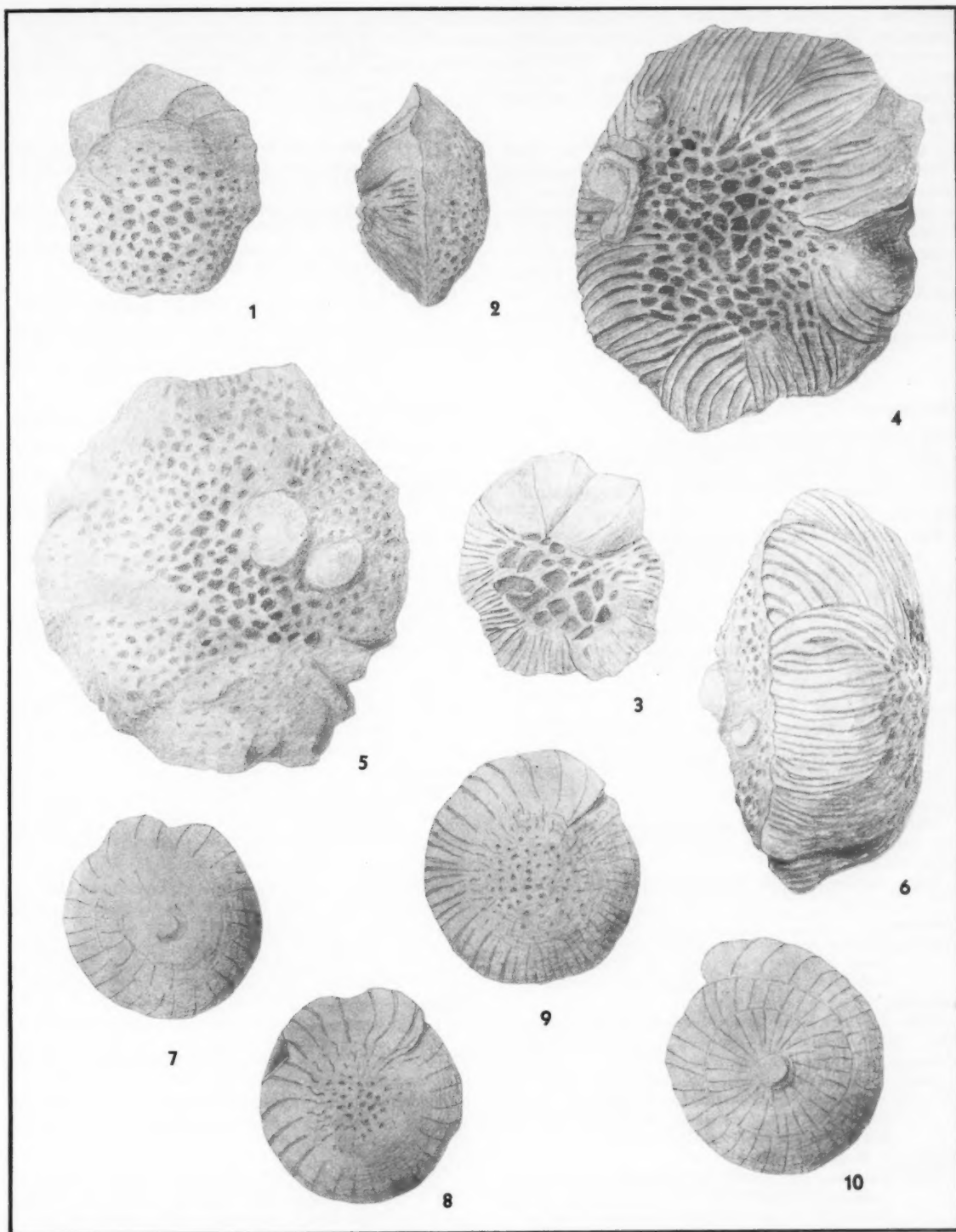
Hypotype, from Truitt station 25663. 1, dorsal view. 2, peripheral view. 3, ventral view. × 115.

4- 6 *Siderolites vanbelleni* (van den Bold)

Hypotype, from Truitt station 25663. 4, ventral view. 5, dorsal view. 6, peripheral view. × 115.

7-10 *Kathina jamaicensis* (Cushman and Jarvis)

Topotypes, from Kozary station 1240. 7, 10, dorsal views. 8-9, ventral views. × 37.



coperculina cf. *s. cosdeni* Applin and Jordan, and rudistid fragments. The fourth sample, from overlying beds, contains a Middle Eocene assemblage of *Pellatispirella matleyi* (Vaughan), *Yaberinella jamaicensis* Vaughan, *Fabularia matleyi* (Vaughan), algae, and mollusk fragments.

In Cuba, *Kathina jamaicensis* was observed by Cole (1942, p. 640) in association with *Sulcoperculinas* and *Meandropsina? rutteni* Palmer. We have also observed it in association with *Sulcoperculinas*, in material from Cuba and Puerto Rico. The genus *Sulcoperculina* Thalmann is known only from Upper Cretaceous strata of the Caribbean region. The occurrence of *Kathina jamaicensis* with fossils that are known only from the Upper Cretaceous indicates that it too is an Upper Cretaceous fossil.

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ABSTRACT: This paper describes and illustrates thirty-three species of foraminifera from Aptian rocks that outcrop in Khashm el Mistan, on the flanks of the great Maghara Dome in northern Sinai. Ten species are described as new. The *Orbitolina* population is very similar to that described by Henson from Lebanon.

Lower Cretaceous foraminifera from Khashm el Mistan, northern Sinai, Egypt

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INTRODUCTION

Outcrops of marine Lower Cretaceous rocks are poorly developed in Egypt, and are found exclusively on the outer flanks of the great Maghara Dome in northern Sinai. The succession there consists predominantly of the Nubian facies, with a few intercalations of shale, marl and limestone that are fossil-bearing and are considered to be of Barremian to Aptian age. There is, in addition, a questionable record of Albian rocks at the entrance to the Gulf of Suez, in Wadi Malaha (van der Ploeg, 1953; Attia and Murray, 1952).

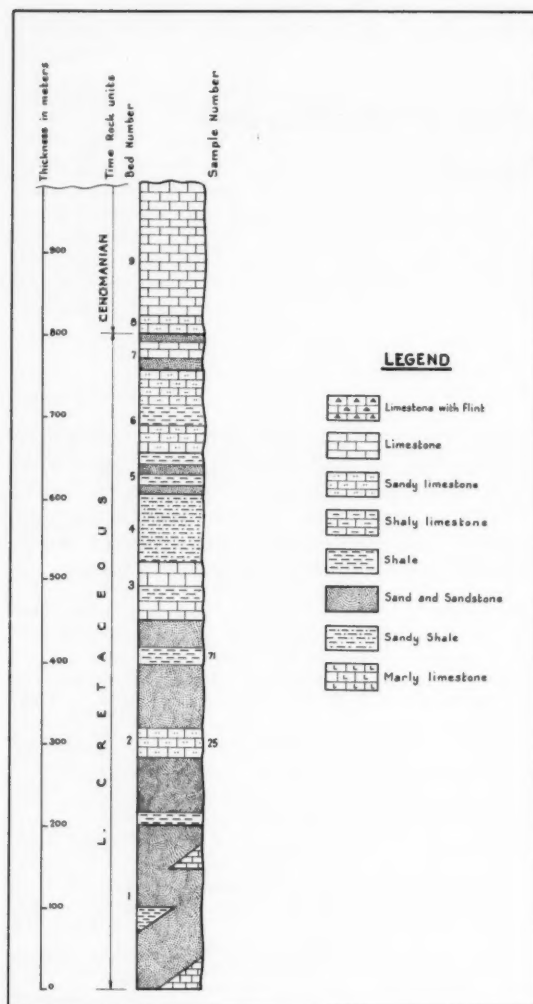
The foraminifera described in this paper come principally from a single bed in the lower part of the Lower Cretaceous of Khashm el Mistan, on the northeast flank of the Maghara Dome. The Lower Cretaceous section of this area, which was described by Moon and Sadek (1921), is about 800 meters thick and is predominantly clastic. The following table (Table 1) is a composite section of the entire Lower Cretaceous as measured along Wadi Rekeib and on Gebel Mistan and Gebel Um Mafrouth, small hillocks lying to the northeast of Maghara. The base of the section is not exposed, and the relationship between the Lower Cretaceous and the underlying exposed Kimmeridgian is not clear (see text-figure 1).

One sample (sample 71) yielded rare specimens of smaller foraminifera. Large quantities of material had to be washed in order to obtain appreciable numbers of specimens. Most of the forms are arenaceous. The species of *Spiroplectammina* are diversified, and constitute some 50 per cent of the entire number of individuals. There are also abundant species of *Flabellammina*. The Lagenidae play a minor role, and the Anomalinidae are insignificant.

In addition, another sample (sample 25) showed, in thin sections, an *Orbitolina* population very similar to that described by Henson (1948) from the Aptian of Lebanon and Syria. It seems possible that the Egyptian Lower Cretaceous was deposited in the same basin as that of the Anti-Lebanon Range.

TABLE 1

Time-rock unit	Bed no.	Description	Thickness in meters	Total thickness in meters
Cenomanian (incomplete)	9	Limestone, white to light gray, hard	200	1020
	8	Sandy limestone, reddish brown to brownish cream	20	820
Lower Cretaceous	7	Sandstone, brown, with interbedded limestone	45	800
	6	Shale with yellowish gray sandy limestone bed	100	755
	5	Alternation of gray shale and yellow sandstone	50	655
	4	Sandy shale, brown, fossiliferous	85	605
	3	Limestone, with gray to yellowish-brown stringers of shale	70	520
	2	Sandstone, limy and shaly at base and near top, with some ferruginous oolites	250	450
	1	Varicolored Nubian sandstone with stringers of shale and limestone	200	200



TEXT-FIGURE 1
Columnar section of Lower Cretaceous in Gebel Maghara.

SYSTEMATIC DESCRIPTIONS

The types and figured specimens have been deposited in the collections of the United States National Museum (U.S.N.M.), Washington, D. C.

All species reported here are from sample no. 71, except *Orbitolina lenticularis*, which is from sample no. 25.

Order FORAMINIFERA

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

Haplophragmoides cf. *globosa* Lozo

Plate 1, figure 28

Haplophragmoides globosa Lozo, 1944, Amer. Midland Nat., vol. 31, p. 543, pl. 2, fig. 8; text-fig. 16.

Test small, involute; periphery broad and rounded; chambers numerous; sutures straight, obscure, the final suture slightly depressed; wall arenaceous, of moderate-sized grains; surface somewhat roughened; aperture seems to be an arch at the base of the apertural face.

Our specimens differ from the type figured by Lozo and subsequent workers in having fewer chambers. A few specimens of this species were found. Hypotype, U.S.N.M. no. P5175.

Genus AMMOBACULITES Cushman, 1910

Ammobaculites agglutinans (d'Orbigny)

Plate 1, figure 4a-b

Haplophragmium agglutinans (d'Orbigny). — MACFADYEN, 1935, Jurassic Foraminifera, p. 9, pl. 1, fig. 1a-b.

Several specimens of this species were found. Figured specimen, U.S.N.M. no. P5152.

Genus FLABELLAMMINA Cushman, 1928

Flabellammina aegyptiaca Said and Barakat, new species

Plate 1, figure 2a-b

Test free, compressed; periphery rounded; chambers coiled in the early portion, later chambers uncoiled, arched, increasing gradually in length as added, much broader than long; sutures generally indistinct, slightly depressed; wall arenaceous, somewhat roughly finished; aperture terminal, slightly elongate. Length 0.85 mm.; breadth 0.5 mm.

This species differs from *Flabellammina compressa* (Beissel) in having a less compressed and smaller test and in having much shorter chambers. It differs from *Flabellammina saratogaensis* Cushman in having the earlier part less developed and more or less in the same axis of growth, and in having a more smoothly finished test.

A large number of specimens of this species were found. Holotype (U.S.N.M. no. P5150) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

EGYPTIAN LOWER CRETACEOUS FORAMINIFERA

Flabellammina macfadyeni Said and Barakat, new species

Plate 1, figure 3a-b

Test elongate, compressed, early coiled portion making up one-fifth of the entire length of the test; periphery rounded; chambers coiled in the early part, distinct; later chambers uncoiled, arched, slightly broader than long, increasing gradually in breadth as added; later uncoiled part with more or less parallel sides; sutures indistinct, slightly depressed, particularly in the last part; wall arenaceous, very smoothly finished; aperture elongate, terminal. Length 0.55 mm.; breadth 0.2 mm.

This species differs from *Flabellammina rugosa* Alexander and Smith in having a much more smoothly finished test and a straighter outline. It differs from *Flabellammina longiuscula* Alexander and Smith in the nature of the aperture and in the size.

Several specimens of this species were found. Holotype (U.S.N.M. no. P5151) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Flabellammina sp.

Plate 1, figure 1

Test much compressed; periphery subrounded; early portion closely coiled, later adult chambers uncoiled, the axis becoming straight; chambers numerous, increasing very slightly in length as added, but flaring and becoming much broader and strongly arched; sutures indistinct, compressed, particularly in the later part; wall coarsely arenaceous, roughly finished; aperture elongate, elliptical, terminal. Length 1.75 mm.; breadth 1.7 mm.

This species may be a variant of *Flabellammina aegyptiaca* Said and Barakat, since it is possible to find intermediate stages between them. Only three specimens of this form were found. Figured specimen, U.S.N.M. no. P5149.

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

Spiroplectammina arabica Said and Barakat, new species

Plate 1, figure 25a-b

Test about twice as long as broad, strongly tapering, greatest breadth and thickness at the apertural end; apertural face slightly concave, subcircular in outline; chambers distinct, numerous, inflated, low, overlapping, the outer end broadly rounded, increasing greatly in breadth as added; sutures distinct, depressed, straight; wall arenaceous but smoothly finished, thick; aperture a low narrow opening at the base of the last chamber, situated in a concavity in the apertural face. The holotype has a small, indistinct, coiled initial part. Length 0.5 mm.; breadth 0.5 mm.

This species differs from *Textularia chapmani* Lalicker in having a concave apertural face and straight sutures. Several specimens of this species were found. Holotype (U.S.N.M. no. P5172) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Spiroplectammina macfadyeni Said and Barakat, new species

Plate 1, figure 19a-b

Test elongate, tapering, greatest breadth and thickness at the apertural end, initial coil very small and twisted, later biserial; chambers numerous, low, increasing gradually in height and breadth as added; sutures flush, distinct, straight; aperture a large semicircular arch at its base of the last-formed chamber. Length 0.5 mm.; breadth 0.3 mm.

This species differs from *Textularia chapmani* Lalicker in its apertural characters, in the nature of the initial end, and in having straight sutures. Several specimens of this species were found. Holotype (U.S.N.M. no. P5166) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Spiroplectammina obscura Said and Barakat, new species

Plate 1, figure 20a-b

Test elongate, tapering, greatest breadth and thickness at the apertural end, oval in section in the early part, subquadrangular in section in the later part; periphery somewhat lobulate; chambers indistinct, not inflated, broader than high, increasing abruptly in size after the addition of the fifth row of chambers; sutures distinct and flush in the early part, somewhat thickened and indistinct in the later part; apertural face slightly concave; aperture a low narrow opening at the inner margin of the apertural face. Length 0.5 mm.; greatest breadth 0.3 mm.; thickness 0.3 mm.

This species differs from *Spiroplectammina alexanderi* Lalicker in having a depressed and distinct earlier portion with flush sutures, and somewhat thickened sutures in the later part. Several specimens of this species were found. Holotype (U.S.N.M. no. P5167) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Genus AMMOBACULOIDES Plummer, 1932

Ammobaculoides sp.

Plate 1, figure 18a-b

Test small, elongate, rounded in cross-section; early portion coiled, nonumbilicate; later biserial; biserial part large, sides nearly parallel; chambers numerous, indistinct; sutures indistinct, straight; wall coarsely arenaceous; aperture terminal and circular. Length 0.45 mm.; breadth 0.1 mm.

A few specimens of this species were found. Figured specimen, U.S.N.M. no. P5165.

Family VERNEUILINIDAE

"Gaudryina" sp.

Plate 1, figure 17a-b

This genus and species will be described as new from the Callovian and Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat, MS.). It has also been found, although less abundant, in the Aptian material from Khashm el Mistan. Figured specimen, U.S.N.M. no. P5164.



TEXT-FIGURE 2

Family ORBITOLINIDAE

Genus ORBITOLINA d'Orbigny, 1850

Orbitolina cf. lenticularis (Blumenbach)

Text-figure 2

Orbitolina lenticularis (Blumenbach). — SILVESTRI, 1932, *Palaeontogr. Ital.*, vol. 32, p. 175, pl. 10, fig. 3.

Orbitolina cf. lenticularis (Blumenbach). — HENSON, 1948, *Larger imperforate foraminifera of south-western Asia*, p. 57, pl. 3, figs. 6-11.

Convexo-concave to conico-concave forms are the dominant shapes of this Aptian species. The apex is rounded, with no supra-embryonic area. The marginal zone is narrow. Parallel sections show a well developed radial zone with straight to flexuous chamber passages leading into a finely woven reticulate zone. The sub-epidermal layer is thin, with regularly arranged secondary cells. Radial chamber passages are small, rounded to triangular, and closely spaced, developing a honey-comb pattern in tangential sections. "Calcite eyes" and quartz grains are particularly evident in oblique sections.

Random sections show that this species is variable, and it is possible that some of the specimens that do not show the subepidermal cells or the marginal chamberlets may belong to *Orbitolina concava* (Lamarck). According to Henson (1948), *Orbitolina lenticularis* is a characteristic Aptian fossil of Lebanon and Syria. It appears to characterize the same level in Egypt. The specimens shown in text-figure 2 are from sample no. 25, Aptian, Khashm el Mistan, northern Sinai.

Family LAGENIDAE

Genus LENTICULINA Lamarck, 1804

Lenticulina münsteri (Roemer)

Plate 1, figure 29

Cristellaria münsteri (Roemer). — REUSS, 1862, *Sitzb. K. Akad. Wiss. Wien*, vol. 46, p. 77, pl. 9, figs. 3a-b, 4a-b.

Several specimens of this species resembling those found in the Bajocian, Callovian and Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat, MS.), were found in the Aptian of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5176.

Genus MARGINULINA d'Orbigny, 1826

Marginulina simplex (Terquem)

Plate 1, figure 13

Vaginulina simplex Terquem. — KARRER, 1861, *Sitzb. K. Akad. Wiss. Wien*, vol. 44, p. 445, pl. 1, fig. 6.

Several specimens that seem to belong to this species and that resemble those of the Bajocian, Bathonian, Callovian and Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat, MS.), were found in the Aptian material studied. Figured specimen, U.S.N.M. no. P5160.

Genus DENTALINA d'Orbigny, 1826

Dentalina pseudocommunis Franke

Plate 1, figure 16

Dentalina pseudocommunis Franke. — BARNARD, 1949, *Quart. Jour. Geol. Soc. London*, vol. 105, p. 464, text-fig. 5k.

Several specimens of this species resembling those of the Bathonian, Callovian and Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat, MS.), were found in the Aptian of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5163.

Dentalina tappanae Said and Barakat, new species

Plate 1, figure 15

Test elongate, slightly arcuate, slender, rounded in cross-section; chambers numerous, as many as six, higher than broad, of uniform shape, increasing gradually in height and very slightly in breadth as added, so that the test is more or less parallel-sided; sutures distinct, depressed, very slightly oblique; wall calcareous, very finely perforate; aperture large, radiate, subterminal. Length 0.5 mm.; diameter 0.05 mm.

EGYPTIAN LOWER CRETACEOUS FORAMINIFERA

This species differs from *Dentalina linearis* (Roemer) in having less inflated chambers, less distinct sutures, and much longer chambers. Several specimens of this species were found. Holotype (U.S.N.M. no. P5162) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Genus NODOSARIA Lamarck, 1816

Nodosaria metensis Terquem

Plate 1, figure 9

Nodosaria metensis TERQUEM, 1863, Mém. Acad. Imp. Metz, vol. 44, p. 377, pl. 7, fig. 5a-b.

A few specimens of this species resembling those of the Bajocian and Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat, MS.), were found in the Aptian of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5157.

Genus RECTOGLANDULINA Loeblich and Tappan, 1955

Rectoglandulina humilis (Roemer)

Plate 1, figure 14

Pseudoglandulina humilis (Roemer). - BARTENSTEIN AND BRAND, 1937, Abh. Senckenb. Naturf. Ges., no. 439, p. 150, pl. 8, fig. 18.

A few specimens of this species resembling those of the Bathonian of Gebel Maghara, northern Sinai (Said and Barakat, MS.), were found in the Aptian of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5161.

Rectoglandulina cf. *mutabilis* (Reuss)

Plate 1, figure 12

Glandulina mutabilis REUSS, 1863 (part), Sitzb. K. Akad. Wiss. Wien, vol. 46, p. 58, pl. 5, figs. 7-8 (not figs. 9-11).

A few specimens that resemble those described from Germany by Reuss are here referred to this species. Our specimens do not have the low early chambers, and the last chamber makes up about one-third of the entire length of the test. Hypotype, U.S.N.M. no. P5159.

Genus TRISTIX Macfadyen, 1941

Tristix mooni Said and Barakat, new species

Plate 1, figure 7a-b

Test narrow, elongate, tapering gradually, greatest breadth at the base of the last chamber, triangular in section, sides very slightly excavated, particularly in the later part, angles acute; chambers increasing gradually in size as added, as many as five in well developed specimens; sutures depressed, distinct, arched at the center of the faces, curving downward at the angles of the test; wall calcareous, finely perforate; surface smooth; aperture terminal and rounded. Length 0.55 mm.; breadth 0.2 mm.

This species differs from *Rhabdogonium insigne* Reuss in having more chambers and in being more elongate. It differs from *Tristix reesidei* Loeblich and Tappan in having fewer chambers and straighter sutures on the faces.

Several specimens of this species were found. Holotype (U.S.N.M. no. P5155) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Genus SARACENARIA DeFrance, 1824

Saracenaria cornucopiae (Schwager)

Plate 1, figure 8

Cristellaria (*Saracenaria*) *cornucopiae* SCHWAGER, 1865, Ver. Vaterl. Naturk. Württemberg, Jahreshefte, vol. 21, p. 121, pl. 5, fig. 7.

Several specimens of this species resembling those of the Kimmeridgian of Gebel Maghara, northern Sinai (Said and Barakat MS.), were found in the Aptian of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5156.

Genus LINGULINA d'Orbigny, 1826

Lingulina furcillata Berthelin

Plate 1, figures 10-11

Lingulina furcillata BERTHELIN, 1880, Mém. Soc. Géol. France, ser. 3, vol. 1, no. 5, p. 65, pl. 4, fig. 6a-c. - TAPPAN, 1943, Jour. Pal., vol. 17, p. 499, pl. 80, fig. 11.

Test elongate, somewhat depressed, uniserial; proloculum ovate, later chambers low and broad at first, arched centrally, increasing in height as added; wall calcareous, very finely pitted; aperture terminal and elongate.

This species, first described from France and later recorded from Germany and the United States Gulf Coast, was found here in small numbers. Hypotypes, U.S.N.M. no. P5158a-b.

Lingulina sadeki Said and Barakat, new species

Plate 1, figure 6a-b

Test elongate, tapering evenly, with the greatest breadth near the base of the last chamber, much compressed, periphery sharply acute; initial end small, proloculum small, globular; chambers distinct, of uniform shape, increasing gradually in size and breadth as added; sutures distinct, depressed, arched centrally; aperture terminal and elongate. Length 0.5 mm.; breadth 0.2 mm.

This species resembles *Fronidularia spissa* Terquem, but differs in the apertural characters and general outline. Several specimens of this species were found. Holotype (U.S.N.M. no. P5154) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Genus CITHARINA d'Orbigny, 1839

Citharina geinitzi (Reuss)

Plate 1, figure 34a-b

Vaginulina geinitzi REUSS, 1874, in GEINITZ, Palaeontographica, vol. 20, p. 91, pl. 21, fig. 1.

Test elongate, arcuate, compressed, broad, smooth; periphery truncate; chambers numerous, low, increasing gradually in breadth as added; sutures flush, thick, more or less radiating from the proloculum, curved; wall smooth, perforate; aperture radiate, at the dorsal angle of the last chamber.

A few specimens of this species were found. Hypotype, U.S.N.M. no. P5180.

Citharina recta (Reuss)

Plate 1, figures 31-32

Vaginulina recta REUSS, 1863, Sitzb. K. Akad. Wiss. Wien, vol. 46, p. 48, pl. 3, figs. 14-15. - TAPPAN, 1943, Jour. Pal., vol. 17, p. 501, pl. 80, fig. 22.

Test elongate, narrow, compressed, parallel-sided, periphery truncate; chambers few, increasing in size from the globular proloculum, which protrudes somewhat above the surface of the remainder of the test; sutures distinct, flush; wall calcareous; surface smooth; aperture radiate, at the dorsal angle, which is produced into a slight neck.

Included under this name are a few specimens whose chambers increase slightly in breadth as added, so that the general outline of the test is acutely triangular. The proloculum is smaller, and it is possible that these specimens represent the microspheric form of *Citharina recta*. Hypotypes, U.S.N.M. no. P5178a-b.

Citharina strigillata (Reuss)

Plate 1, figure 30

Vaginulina (Citharina) strigillata REUSS, 1846, Verstein. Böhm. Kreideform., vol. 2, p. 106, pl. 24, fig. 29.

Test depressed, triangular in outline; chambers numerous, each extending ventrally nearly to the base; sutures distinct, thickened; wall calcareous, finely perforate; aperture radiate, at the dorsal angle of the last chamber.

A few specimens of this species were found. Hypotype, U.S.N.M. no. P5177.

Citharina cf. striolata (Reuss)

Plate 1, figure 33a-b

Vaginulina striolata REUSS, 1864, Sitzb. K. Akad. Wiss. Wien, vol. 46, pl. 3, fig. 7.

Test elongate, narrow, compressed, periphery truncate; chambers arcuate, of uniform shape, very slightly increasing in size as added; sutures distinct, somewhat thickened, curving backward to the initial part of the

test; wall smoothly finished, with faint striations that are very oblique to the sutures. In this latter respect, our specimens differ from those figured by Reuss, but they agree well in all other characters and in dimensions.

Several specimens of this species were found. Hypotype, U.S.N.M. no. P5179.

Family POLYMORPHINIDAE

Genus EOGUTTULINA Cushman and Ozawa, 1930

Eoguttulina polygona (Terquem)

Plate 1, figure 26

Eoguttulina polygona (Terquem). - CUSHMAN AND OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 17, pl. 1, fig. 1.

Several specimens of this species resembling those of the Bajocian, Callovian and Kimmeridgian of Gebel Maghara (Said and Barakat, MS.) were found in the Aptian rocks of Khashm el Mistan. Figured specimen, U.S.N.M. no. P5173.

Family ELLIPSOIDINIDAE

Genus NODOSARELLA Rzehak, 1895

Nodosarella sp.

Plate 1, figure 5a-b

Test small, slender, elongate, tapering, greatest breadth at the middle of the last chamber; chambers distinct, increasing rather rapidly in diameter and increasing much in length as added, somewhat inflated; sutures distinct, depressed; wall smooth, somewhat pitted; aperture elliptical, at one side of the end of the last-formed chamber.

Only two specimens of this species were found. Hypotype, U.S.N.M. no. P5153.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

Discorbis beadnelli Said and Barakat, new species

Plate 1, figure 21a-c

Test depressed, concavo-convex, rounded in outline, periphery subrounded, lobulate; dorsal side convex; made up of two whorls; ventral side umbilicate; chambers distinct, five or six in the final whorl, o; uniform shape, increasing gradually in size as added; wall perforate; sutures very slightly oblique, depressed; aperture an elongate slit at the base of the last-formed chamber, extending into the umbilicus. Diameter 0.3 mm.; thickness 0.2 mm.

EGYPTIAN LOWER CRETACEOUS FORAMINIFERA

This species may belong to the genus *Rosalina* d'Orbigny, 1826. The tendency of the species to develop irregular shelly deposits in the umbilical region, as well as the presence of slightly developed apertural flaps, particularly in the last few chambers, gives it the appearance of *Discopulvinulina* Hofker, 1951. This is a distinct species, which resembles some of the more modern species of "*Discorbis*."

Several specimens of this species were found. Holotype (U.S.N.M. no. P5168) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina infracretacea Glaessner

Plate 1, figure 27a-c

Globigerina infracretacea GLAESSNER, 1937, Moscow, Univ., Studies in Micropal., vol. 1, no. 1, p. 28, text-fig. 1.

Globigerina cretacea d'Orbigny. - TAPPAN, 1943, Jour. Pal., vol. 17, p. 512, pl. 82, figs. 16-17.

Test trochoid; periphery broadly rounded; chambers inflated, globular, five in the last whorl; sutures distinct, deeply depressed, straight; wall calcareous, perforate, somewhat hispid; aperture extending from the periphery into the umbilical area.

Abundant specimens of this species occur in the Lower Cretaceous of both Europe and North America, as well as in the Aptian material studied from Khashm el Mistan. Hypotype, U.S.N.M. no. P5174.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

Anomalina humei Said and Barakat, new species

Plate 1, figure 24a-c

Test small, slightly compressed; periphery rounded; chambers numerous, increasing gradually in size, seven or eight occurring in the last whorl, all visible on the dorsal side, only those of the last-formed coil visible on the ventral side, ventral side umbilicate; sutures indistinct, depressed; wall thin, perforate; aperture a narrow curved slit at the base of the last-formed chamber. Diameter 0.2 mm.

This species, which is common in the material studied, differs from *Anomalina clementiana* (d'Orbigny) in general appearance and in having depressed sutures. It differs from *Anomalina rudis* (Reuss) in having a smaller test, an

open umbilicus, and an aperture that does not extend to the umbilicus. Holotype (U.S.N.M. no. P5171) from sample no. 71, Aptian, Khashm el Mistan, northern Sinai.

Genus ANOMALINOIDES Brotzen, 1942

Anomalinoides rudis (Reuss)

Plate 1, figure 23a-c

Rosalina rudis REUSS, 1863, Sitzb. K. Akad. Wiss. Wien, vol. 46, p. 87, pl. 11, fig. 7a-c.

Anomalina rudis (REUSS). - TEN DAM, 1950, Mém. Soc. Géol. France, vol. 29, no. 4, p. 56, pl. 4, fig. 8.

Specimens resembling those recorded by ten Dam from the Albion of the Netherlands were found in the Aptian of Khashm el Mistan. Our specimens lack the distinct boss that appears in ten Dam's material. Hypotype, U.S.N.M. no. P5170.

Anomalinoides? sp.

Plate 1, figure 22a-c

Test concavo-convex, depressed, involute, ventrally umbilicate; periphery lobulate, acute; chambers few, four in the last whorl; sutures distinct, depressed, curved to the periphery; aperture a slit at the base of the last-formed chamber, extending to the umbilicus.

This species does not show many of the characteristics of the genus, and is here provisionally placed in *Anomalinoides*. A few specimens were found. Figured specimen, U.S.N.M. no. P5169.

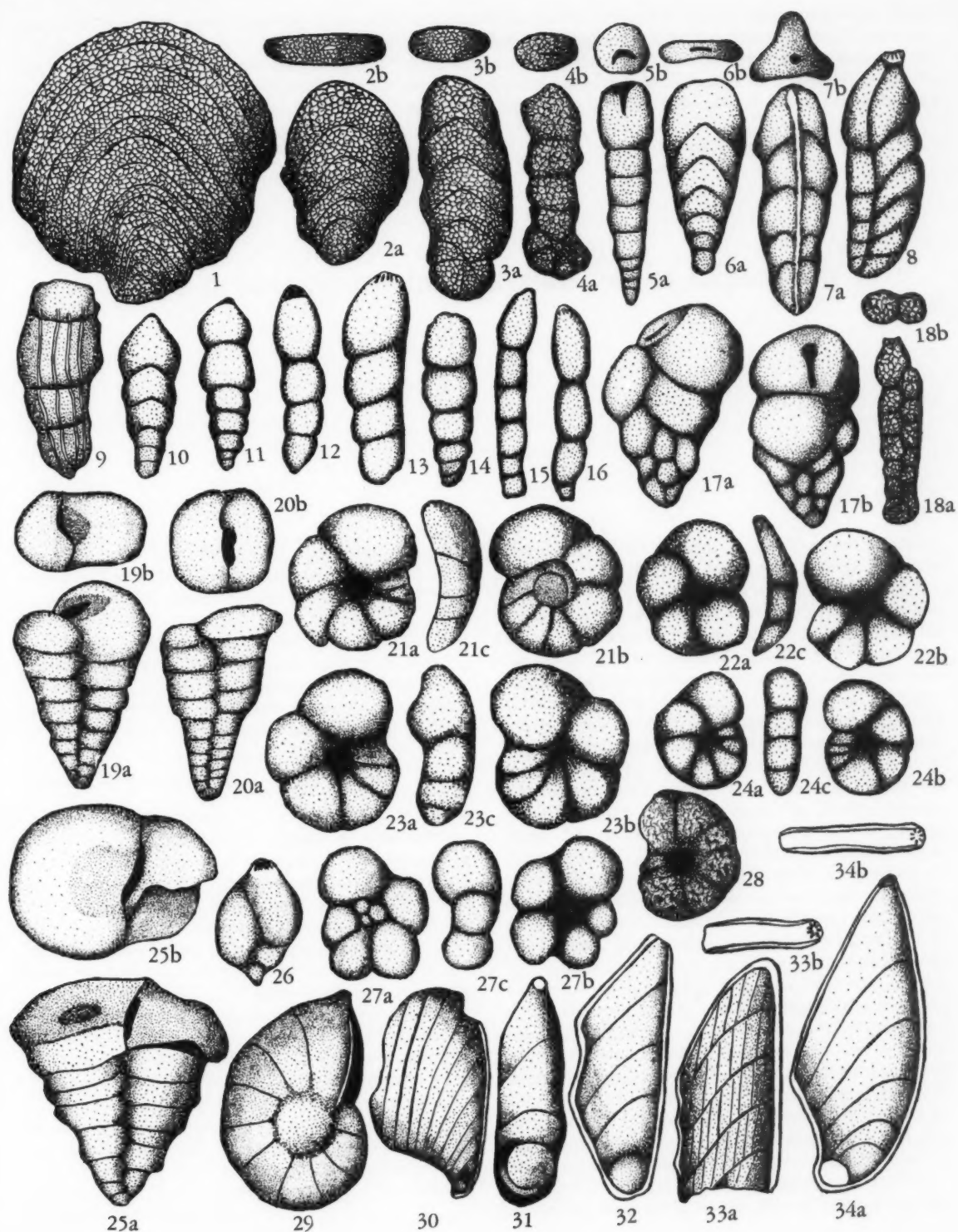
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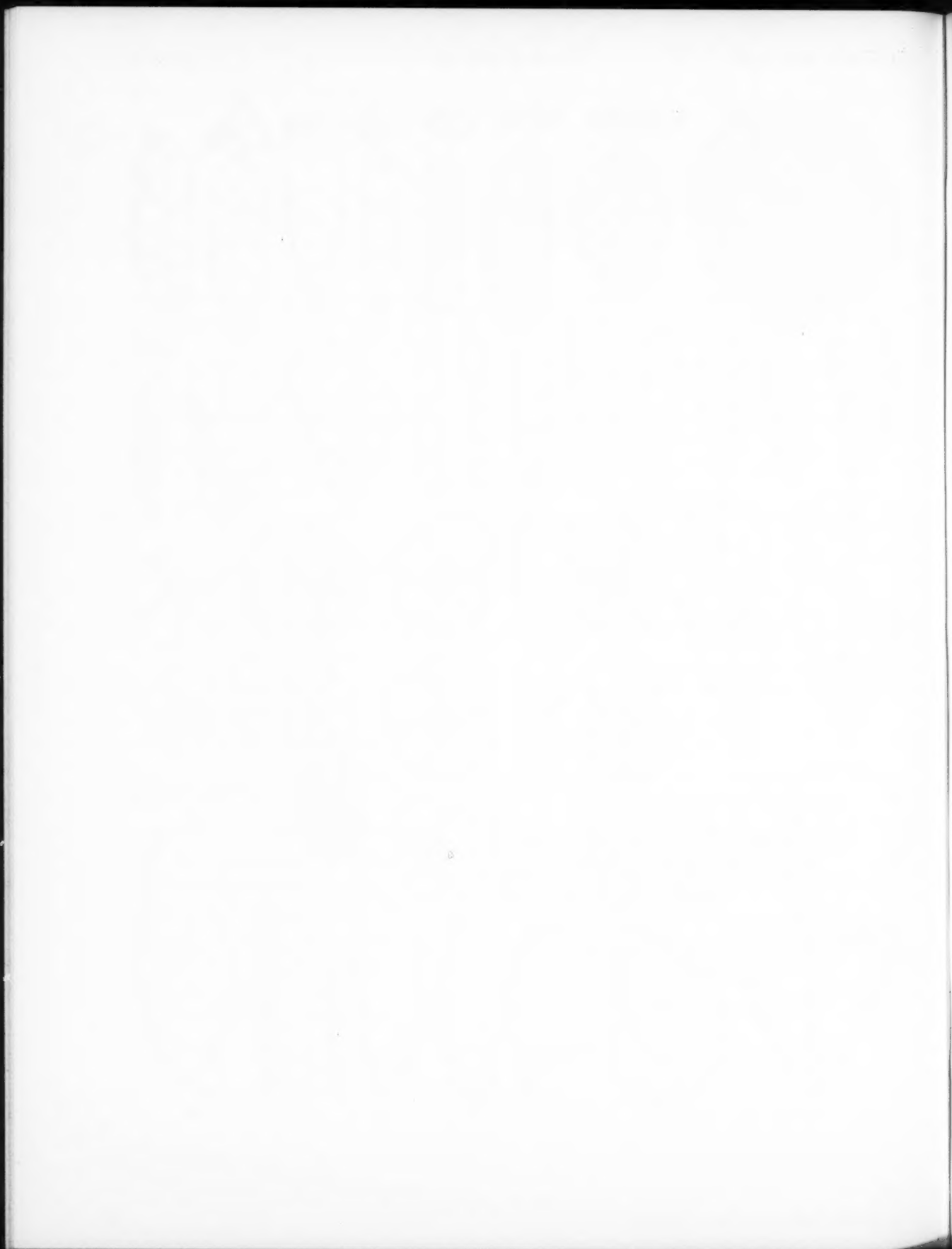
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PLATE 1

All specimens are from sample no. 71, Aptian, Khasm el Mistan, northern Sinai, Egypt. All figures $\times 80$ unless otherwise indicated.

- 1 *Flabellamina* sp., $\times 30$.
- 2 *Flabellamina aegyptiaca* Said and Barakat, n. sp.
a-b, lateral and apertural views of holotype,
 $\times 40$.
- 3 *Flabellamina macfadyeni* Said and Barakat, n. sp.
a-b, lateral and apertural views of holotype.
- 4 *Ammobaculites agglutinans* (d'Orbigny)
a-b, lateral and apertural views.
- 5 *Nodosarella* sp.
a-b, lateral and apertural views.
- 6 *Lingulina sadeki* Said and Barakat, n. sp.
a-b, lateral and apertural views of holotype.
- 7 *Tristix mooni* Said and Barakat, n. sp.
a-b, lateral and apertural views of holotype.
- 8 *Saracenaria cornucopiae* (Schwager)
- 9 *Nodosaria metensis* Terquem
- 10-11 *Lingulina furcillata* Berthelin
Two views of two different specimens.
- 12 *Rectoglandulina* cf. *mutabilis* (Reuss)
- 13 *Marginulina simplex* (Terquem)
- 14 *Rectoglandulina humilis* (Roemer)
- 15 *Dentalina tappanae* Said and Barakat, n. sp.
Holotype.
- 16 *Dentalina pseudocommunis* Franke
- 17 "Gaudryina" sp.
a-b, lateral and apertural views.
- 18 *Ammobaculoides* sp.
a-b, lateral and apertural views.
- 19 *Spiroplectamina macfadyeni* Said and Barakat,
n. sp.
a-b, lateral and apertural views of holotype.
- 20 *Spiroplectamina obscura* Said and Barakat, n.sp.
a-b, lateral and apertural views of holotype.
- 21 *Discorbis beadnelli* Said and Barakat, n. sp.
a-c, ventral, dorsal, and apertural views
of holotype.
- 22 *Anomalinoides?* sp.
a-c, ventral, dorsal, and apertural views.
- 23 *Anomalinoides rudis* (Reuss)
a-c, ventral, dorsal, and apertural views.
- 24 *Anomalina humei* Said and Barakat, n. sp.
a-c, ventral, dorsal, and apertural views
of holotype.
- 25 *Spiroplectamina arabica* Said and Barakat, n. sp.
a-b, lateral and apertural views of holotype.
- 26 *Eoguttulina polygona* (Terquem)
- 27 *Globigerina infractetacea* Glaessner
a-c, dorsal, ventral, and apertural views.
- 28 *Haplophragmoides* cf. *globosa* Lozo, $\times 40$.
- 29 *Lenticulina münsteri* (Roemer)
- 30 *Citharina strigillata* (Reuss), $\times 40$.
- 31-32 *Citharina recta* (Reuss)
Two views of two different specimens.
- 33 *Citharina* cf. *striolata* (Reuss)
a-b, lateral and apertural views, $\times 40$.
- 34 *Citharina geinitzi* (Reuss)
a-b, lateral and apertural views.





ABSTRACT: Important papers concerning *Diplopora annulatissima* Pia are reviewed in order to discuss its geologic range. With regard to the subdivision of *Diplopora annulata* Schafhäütl, it is proposed to reject the three varieties (*dolomitica*, *septentrionalis* and *debilis*) and the two "forms" (*trichophora* and *vesiculifera*) because they were established on the improbable supposition of sexual dimorphism in the species *Diplopora annulata*. In their stead, it is proposed to use the characters of the "forms" in establishing two new subspecies: *Diplopora annulata* Schafhäütl subsp. *annulata* and *Diplopora annulata* Schafhäütl subsp. *dolomitica*.

Some problems in the dasyclad genus *Diplopora*

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INTRODUCTION

Everyone who has dealt with *Diplopora annulata* Schafhäütl and *Diplopora annulatissima* Pia must have encountered difficulties in distinguishing one from the other and in determining the infraspecific taxa of *Diplopora annulata*. For this reason, it seems to be necessary to review the main principles upon which Pia based the taxonomic interpretation of the two species. In addition, it appears desirable to discuss the geologic range of *Diplopora annulatissima*.

DIPLOPORA ANNULATISSIMA PIA

The problems encountered with regard to this species are manifold. They include nomenclatural priority, variability and relationships with *Diplopora annulata*, and geologic range. A comparison of some published figures of *Kantia monregalensis* (Baretti, 1919, fig. 6) with those of the type specimens of *Diplopora annulatissima* (Pia, 1920, pl. 4, figs. 12-14) leaves no doubt that they are the same species. The question of nomenclatural priority therefore must be resolved. If *Kantia monregalensis* had been validly published, the name of the species would now be *Diplopora monregalensis* (Baretti), as the name *Kantia* has been rejected. This is impossible, however, because heterogeneous specimens were figured under the name *Kantia monregalensis*, and the description does not correspond to specimens that are now regarded as true representatives of the species in question. We must therefore retain the name *Diplopora annulatissima* Pia.

If only the type specimens of *Diplopora annulatissima*, together with their description and original restoration (Pia, 1920), are taken as the standard of the species, many difficulties arise in the identification of new specimens, because the type specimens do not show the true range of variability of the species. Pia himself sometimes expressed doubt and uncertainty in identifying new specimens. Furthermore, he identified some specimens as *Diplopora annulatissima* even though they did not completely correspond to the type specimens (Pia, 1924). I have also encountered similar difficulties in identifying some Ladinian specimens from the Dinaric Mountains. In revising the description of the species (Herak, 1951), I attempted to find the most characteristic features which would make it possible to distinguish *Diplopora annulatissima* from *Diplopora annulata*. It was found that *Diplopora annulatissima* has a rather large range of variation with regard to the dimensions of the main stem, the furrows between two neighboring segments, and the dimensions of branches. On the other hand, the segmentation of the calcareous envelope is very regular and constant. Each segment contains only one whorl of branches. On this basis, the majority of the Ladinian specimens with one whorl in each segment were identified as *Diplopora annulatissima*. With regard to the shape of branches, it was emphasized in the original description that their proximal portions are enlarged and their distal portions thin (Pia, 1920). However, inasmuch as the closely related species

Diplopora annulata and *Diplopora uniserialis* have two types of branches, we should not, *a priori*, exclude the possibility that there are different types of branches in *Diplopora annulatissima* as well.

In order to discuss the geologic range of *Diplopora annulatissima*, it is necessary to give a brief review of the more important papers concerning this problem. This review shows the insufficiency of evidence upon which the geologic range has been determined.

Baretti (1919) compared the fossiliferous limestone containing "*Kantia monregalensis*" with the Ladinian Wettersteinkalk. The type specimens of *Diplopora annulatissima* were found in limestone at Zweckenalp bei Mythen and at Teurihorn, in Switzerland; this limestone had previously also been considered equivalent to the Ladinian Wettersteinkalk. Pia (1920, p. 117) believed that the dasyclad flora to which *Diplopora annulatissima* belonged had an Anisian rather than a Ladinian character; this was the first occasion on which *Diplopora annulatissima* was thought to be an Anisian fossil.

In 1907, Ogilvie Gordon found dasyclad remains in the southern Alps in a horizon composed of thin-bedded bituminous limestone and cherty limestone, and also in the dolomitic facies that stratigraphically follows the Anisian Mendola dolomite. She correlated these sediments with the upper Anisian of the northern Tyrol even before she determined the dasyclad remains as *Diplopora annulatissima*. She regarded the occurrence of this alga as further proof of their upper Anisian age (Ogilvie Gordon, 1925, 1927).

Pia (1931) believed that the lower portion of the Himmelwitz dolomite of Silesia undoubtedly belongs to the Anisian stage. In later papers, he also regarded *Diplopora annulatissima* as an index fossil for the upper Anisian (Pia, 1930, 1936, 1937a, b). However, it must not be forgotten that this conclusion has not been adequately documented, inasmuch as none of the localities mentioned has been proved to be Anisian on the basis of its fossils.

In a short note on the limestone with dasyclads that occurs between Rašica and Turjak in Slovenia, Uršič (1937) listed *Diplopora annulatissima* among the Anisian species *Physoporella pauciforata* Gümbel, *Oligoporella prisca* Pia, *Diplopora subtilis* Pia, *Physoporella dissita* Gümbel, and *Teutloporella hirsuta* Pia. Unfortunately, he did not indicate whether these species were found at the same or at different localities. If they were found together, this occurrence would mark the only certain Anisian locality

for *Diplopora annulatissima*. In view of the fact that this species is absent from all localities of Anisian dasyclads in Croatia and Bosnia, there is little reason to suppose that they were actually found together.

As can be seen, a chronological review of papers concerning *Diplopora annulatissima* reveals that the majority of localities do not yield the information necessary for a precise determination of the horizon of the fossiliferous beds. The only exceptions are the transition zone between the Mendola dolomite and the Buchenstein beds with green tuffs in the southern Alps, and the Himmelwitz dolomite in Silesia. Even in these cases, however, we cannot accept the upper Anisian age of the sediments as proved. Mojsisovics considered the transition zone in the southern Alps to be the lower portion of the Buchenstein beds. Ogilvie Gordon emended this opinion on the basis of correlation of facies. The absence of green tuffs in the transition zone was especially emphasized. Bearing in mind the great differentiation of facies in the Middle Triassic of the Alps, it is easy to realize that a stratigraphic subdivision based only on facies is rather uncertain. If the presence of tuffs is accepted as proof of the presence of Buchenstein beds, then even the thin-bedded gray dolomite of the southern slope of Sarkofl can not be regarded as a part of the Buchenstein beds. However, Pia (1937a), who certainly was well acquainted with the Middle Triassic of the Alps, defined these sediments as "dolomitisierte Buchensteiner Schichten." He also states: "Es besteht nach diesen Befunden kein Zweifel, dass der Uebergang vom Sarldolomit zu den Buchensteiner Schichten recht allmählich in einem ziemlich breiten Gesteinsstreifen erfolgt, u. zw. gehört die ganze Uebergangszone augenscheinlich schon der Zeit an, in der an anderen Stellen der Karte bereits Buchensteiner Schichten abgesetzt wurden" (Pia, 1937a, p. 49). It is undoubtedly true that the deposition of typical Buchenstein beds did not occur simultaneously over the entire area of the southern Alps. Consequently, typical composition cannot be regarded as a certain criterion in correlation. The fossiliferous horizon between the Mendola dolomite and the Buchenstein beds may therefore belong equally well to the Ladinian stage. With regard to the Himmelwitz dolomite of Silesia, there is also no reason why the dolomite, as a whole, should not belong to the Ladinian stage.

The only stratigraphically determined localities of *Diplopora annulatissima* are therefore those in the Dinaric Mountains, where the fossiliferous limestone corresponds to the Ladinian stage. Accordingly,

instead of an Anisian index fossil, we are dealing with a species which occurs without doubt in Ladinian sediments, whereas its Anisian localities are still uncertain.

DIPLOPORA ANNULATA SCHAFFHÜTL

This species has been dealt with repeatedly in Pia's taxonomic and biostratigraphic papers. He has changed its original definition and diagnostic description (Pia, 1920). According to his most recent opinion, *Diplopore annulata* comprises three varieties, *dolomitica*, *septentrionalis* and *debilis*, and two "forms," *trichophora* and *vesiculifera*, which he believes represent two different sexes. However, in practice it has proved difficult to distinguish them, and in many cases this has been merely a question of personal opinion. Moreover, if only a few specimens were found at a given locality, it has been impossible to determine the variety. For this reason, it is believed necessary to revise the subdivision of *Diplopore annulata*. In this connection, it seems appropriate to start with Pia's concept of the "forms."

The principal morphologic characters of the "forms" are based on the shape of the branches. "Forma *trichophora*" includes all specimens with thin branches that pierce through the calcareous envelope and are prolonged as very thin growths (assimilators). "Forma *vesiculifera*," on the other hand, includes specimens with branches that are enlarged in their distal portion, thus becoming club-like. They remain within the calcareous envelope. In Pia's opinion these differences were due to shifting the formation of "spores" from the main stem to the branches.

At first (1912), Pia considered the shape of the branches very important taxonomically, and he described the species *Kantia dolomitica* as including only specimens with vesiculiferous branches. Later (1920), Pia changed his opinion and transferred the specimens with vesiculiferous branches to the species *Diplopore annulata*, rejecting the name *Kantia* completely. The epithet "*dolomitica*" was retained for a new variety of the species *Diplopore annulata*. This was an alteration not only in the rank but also in the diagnostic description: The new variety was described as including not only specimens with vesiculiferous branches, but also specimens with the trichophorous type. Moreover, two more varieties were described, with the epithets "*septentrionalis*" and "*debilis*" (after the rejected species *Diplopore debilis*). Among these varieties, specimens with vesiculiferous branches are in the minority. Because the "forms" were not intended to represent taxa, but merely different sexes of the species *Diplopore*

annulata, the two "form" names were used in all three varieties. The variation in the number of specimens with vesiculiferous branches among the three was believed to be caused by external influences, and the varieties were thought to correspond to geographic races (Pia, 1920). There is no firm criterion for identifying them, however. Consequently, it is possible for such terms to have different meanings, not only in papers by different authors, but also very often in papers by the same author.

The central problem relates to the supposed sexual dimorphism upon which the definitions of the varieties were based. There are three reasons why Pia (1920) assumed the existence of sexual dimorphism in *Diplopore annulata*: The first was the fact that no sample has yet been found containing only specimens with vesiculiferous branches, whereas samples containing only specimens with trichophorous branches do exist. This argument cannot be accepted if we consider, as Pia himself did, that vesiculiferous branches represent a progressive type that originated after the trichophorous type. Accordingly, the existence of samples with specimens possessing only trichophorous branches is normal, at least at the beginning of the development of *Diplopore annulata*. An increase in the number of specimens with vesiculiferous branches can be expected only in the younger beds of the Ladinian stage. This is actually the case in the Dinaric Mountains, where an upper Ladinian age has been demonstrated for many localities that are rich in specimens with vesiculiferous branches. Consequently, morphologic differences in the branches are to be regarded as representing different stages of evolution rather than sexual dimorphism.

As his second reason, Pia mentioned the existence of forms intermediate between specimens with trichophorous branches and those with vesiculiferous ones. Among all known specimens, only the one figured by Pia (1912, pl. 4, fig. 16) was identified as an intermediate form because it possesses both types of branches, trichophorous in the lower and vesiculiferous in the higher portion of the stem. No similar specimens have been found since that time. Some doubt may therefore be justifiable concerning the interpretation of this one individual. Even if this interpretation were correct, however, it would be easier to explain this phenomenon on the basis of the biogenetic law. In that case, we would not be concerned with a form intermediate between two sexes, but with an individual in which the phylogenetically more primitive type of branches has developed in the basal portion of the stem, which represents an earlier ontogenetic stage.

Pia's third reason was the fact that both types of branches are found in all three varieties, although they are present in variable numbers. The existence of sexual dimorphism was assumed in drawing up the definitions of the varieties. Therefore, it is impossible to use the definitions themselves as proof of the truth of the original assumption.

In connection with sexual dimorphism in *Diplopora annulata*, it should be noted that among Recent dasyclads, similar examples with which to compare it have not been found. Moreover, such a comparison has proved to be impossible within the whole group of Chlorophyceae. Pia (1920) therefore looked for analogous examples among the other algal groups, but without success. The comparisons made in his paper with *Cutleria*, *Aglaozonia*, and other forms were not, as Pia himself said, made "im Sinne einer genauen Analogie." Actually, *Cutleria* and *Aglaozonia* cannot be compared with *Diplopora* in this respect, because they represent different generations (gametophyte and sporophyte), and not different sexes of the gametophyte as was believed to be the case with the "forms" of *Diplopora annulata*.

In the light of all that has been said above, there appears to be no argument in favor of sexual dimorphism in *Diplopora annulata*. On the other hand, there are two very important arguments against such an assumption — the absence of sexual dimorphism in Recent dasyclads, and the younger geologic age of the specimens with vesiculiferous branches.

Because the concept of the varieties was based on an assumption of sexual dimorphism, it is clear that an emendation of the subdivision of *Diplopora annulata* is necessary. In order to do this, it seems best to reject all three varieties, because they were established on unproven assumptions, and to return to the fixed morphologic features of the species. Since differences in the shape of the branches are the most evident and constant characters, they seem to be highly appropriate characters upon which to base a new subdivision of the species *Diplopora annulata* into two subspecies. (The taxon "variety" must be avoided, because the new varieties might be confused with the rejected ones.)

One subspecies includes all specimens of *Diplopora annulata* that possess vesiculiferous branches. According to the principle of priority, this subspecies

must be named with the epithet of *Kantia dolomitica*, which was validly published. This new taxonomic concept is merely an alteration in rank. The full name of the new subspecies is therefore *Diplopora annulata* Schafhäütl subsp. *dolomitica* (Pia), n. subsp.

The second subspecies includes all specimens of *Diplopora annulata* with trichophorous branches. These specimens are, in fact, the type specimens of the species, and this subspecies must therefore be named *Diplopora annulata* Schafhäütl subsp. *annulata*, n. subsp. With regard to the geologic range, it should be noted that both subspecies extend to the upper Ladinian, as has been established in many localities in the Dinaric Mountains.

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ABSTRACT: *Smaller foraminifera from several samples of the Bartonian of Barton, Hampshire, England, are recorded and described. The faunule is compared with that of the London Clay (Lower Eocene) and the marine Oligocene of England.*

Smaller foraminifera from the Upper Eocene of Barton, Hampshire, England

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INTRODUCTION

Although the larger foraminifera of the Bartonian are referred to in several comparatively recent papers, among the most important being that on the English Bartonian Nummulites by Curry (1937), the smaller foraminifera have been either ignored or inadequately treated. During the years 1950 to 1952, the author investigated the foraminifera of the London Clay (see Bowen, 1945a), and the present paper is a continuation of work on Eocene smaller foraminifera. It is hoped that an analysis of those from the Thanetian will be completed later. A zonal scheme for the entire British Eocene may then become possible.

STRATIGRAPHY

The accompanying map (text-figure 1) shows the geographic location of Barton, and the following details of the lithology are relevant. The strata are the highest in the Eocene succession, and, apart from the type area (in Christchurch Bay), outcrop at Alum and Whitecliff Bays in the Isle of Wight. They were laid down under marine conditions, and vary in thickness from 192 feet at Barton to 368 feet at Whitecliff Bay.

The lower Barton beds consist of greenish sandy clay passing into loams near the top, and yield many mollusks, some of which resemble forms living near Australia and Japan at the present day. Corals, echinoids, fish, turtles and crabs have also been recorded. Poorly preserved plants occur, and occasional concretions of clay-ironstone are found.

The middle Barton beds are primarily clays with layers of tabular septaria. Numerous macrofossils occur, and this division includes the upper half of the Barton Clay in the type section.

The upper Barton beds begin with the *Chama* bed consisting of bluish sand in the type area. Above this is the Barton Sand, with many shells, among which are some of the lower Barton species that are absent from the middle beds. At the end of the Bartonian, conditions became brackish, approaching the succeeding fresh-water lower Headon beds of basal Oligocene age. All the foraminifera noted in the present paper were obtained from the Bartonian of Barton itself.

CLASSIFICATION

The classification proposed by Cushman (1948) has been followed because it is widely used and therefore facilitates comparison with the work of others. Twenty-two species are described, and a number of them are illustrated. The families are arranged in alphabetical order, and representative specimens have been presented to the Trustees of the British Museum (Natural History), London.

SYSTEMATIC PALEONTOLOGY

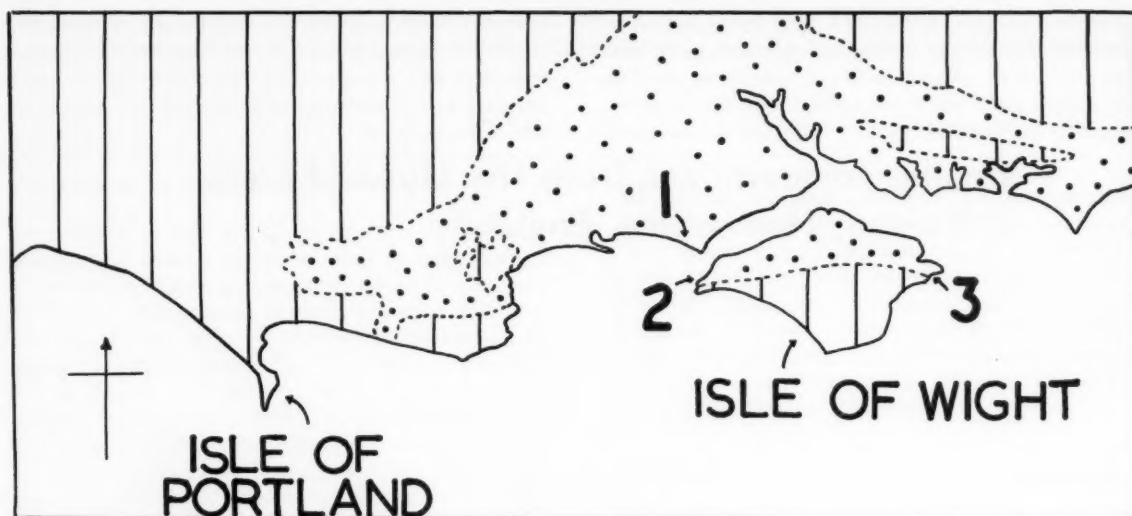
Order FORAMINIFERA

Family ANOMALINIDAE

Subfamily CIBICIDINAE

Genus *Cibicides* Montfort, 1808

There is some confusion in the literature regarding the use of the terms "ventral" and "dorsal" within this genus. Cushman (1948) and Samoilova (1947) both regard the evolute side as the dorsal and the involute as the ventral. Plummer (1927) defines them to the contrary. The present author has adopted the former usage.



TEXT-FIGURE 1

MAP SHOWING LOCALITIES MENTIONED IN THIS PAPER

1 = Christchurch Bay, in which the Bartonian outcrops at Barton Cliff, the type section. 2 = Alum Bay, Isle of Wight. 3 = Whitecliff Bay, Isle of Wight. The dotted areas comprise the Hampshire Basin tectonic basin of Tertiary deposits, and the ruled areas consist of pre-Tertiary rocks.

***Cibicides aknerianus* (d'Orbigny)**

Rotalina akneriana D'ORBIGNY, 1846, Foram. Foss. Bass. Tert. Vienne, p. 156, pl. 8, figs. 13-15.
Cibicides akneriana (d'Orbigny). - NUTTALL, 1932, Jour. Pal., vol. 6, p. 32, pl. 9, figs. 1-3.

The range of this species is given as Eocene to Miocene by Bhatia (1955). Rare.

***Cibicides lobatulus* (Walker and Jacob)**

Nautilus lobatulus WALKER AND JACOB, 1798, Adam's Essays, p. 642, pl. 14, fig. 36.
Cibicides lobatula (Walker and Jacob). - CUSHMAN, 1931, U. S. Nat. Mus., Bull., no. 104, p. 118, pl. 21, fig. 3.

Although much less evolute dorsally, *Cibicides dutemplei* (d'Orbigny) var. *oligogenicus* Samoilova, 1947, resembles the present species closely. *Cibicides lobatulus* shows great morphological variation; this fact was noted by Brady (1884), who stated that it may intergrade with several others. Frequent.

***Cibicides refulgens* Montfort**

Hammonia Balanus seu Balanoidea SOLDANI, 1798, Testaceographia, vol. 1, pt. 1, p. 58, pl. 46, figs. nn, oo.
Cibicides refulgens MONTFORT, 1808, Conchyliologie systématique, vol. 1, p. 123.

Rare.

***Cibicides vulgaris* (Plummer)**

Plate 1, figure 1

Truncatulina vulgaris PLUMMER, 1927, Texas, Univ., Bull., no. 2644 (1926), p. 145, pl. 10, fig. 3.
Cibicides vulgaris (Plummer). - BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 136.

Plummer (1927) noted the variation in the degree of development of limbation in this species, some specimens having well marked spirals of calcareous material on each side. The lack of limbation on the ventral side, and the greater compression, distinguish *Cibicides* *io* Cushman, 1931, from the present species. *Cibicides allenii* (Plummer) is similar, but has more chambers in the last whorl. It is possible that that species should be reduced to the rank of a variety of *Cibicides vulgaris*. Rare.

Family BULIMINIDAE**Subfamily TURRILININAE**

Genus *BULIMINELLA* Cushman, 1911

***Buliminella elegantissima* (d'Orbigny)**

Plate 1, figure 17

Bulimina elegantissima D'ORBIGNY, 1839, Voyage dans l'Amérique Méridionale; Foraminifères, vol. 5, pt. 5, p. 51, pl. 7, figs. 13-14.

Buliminella elegantissima (d'Orbigny). - CUSHMAN, 1911, U. S. Nat. Mus., Bull., no. 71, pt. 2, p. 89.

BARTONIAN SMALLER FORAMINIFERA

Frequent in the Bartonian and continuing into Recent seas. This species does not occur in the London Clay, and hence presumably originated in Middle Eocene time.

Family CHILOSTOMELLIDAE

Subfamily ALLOMORPHINELLINAE

Genus *Pullenia* Parker and Jones, 1862

Pullenia quinqueloba (Reuss)

Plate 1, figure 16

Nonionina quinqueloba REUSS, 1851, Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 71, pl. 5, fig. 31.

Pullenia quinqueloba (Reuss). — BRADY, 1882, Proc. Roy. Soc. Edinburgh, vol. 11, p. 712.

Considerable morphological variation exists within this species, but the author has adopted the suggestion of Stainforth (1949) that "much confusion would be eliminated by referring all specimens of compressed, slightly lobulate *Pullenia* to the single species *Pullenia quinqueloba* (Reuss)." Rare.

Family LAGENIDAE

Subfamily LAGENINAE

Genus *Lagena* Walker and Boys, 1784

Lagena striata (d'Orbigny)

Oolina striata D'ORBIGNY, 1839, Voyage dans l'Amérique Méridionale; Foraminifères, vol. 5, pt. 5, p. 21, pl. 5, fig. 12.

Lagena striata (d'Orbigny). — REUSS, 1863, Sitzb. Akad. Wiss. Wien, vol. 46, p. 327, pl. 3, figs. 44-45.

Heron-Allen and Earland (1932) believed that "many striatas may be assigned to weak sulcatas," and Bagge (1912) pointed out that "reduction of the striations and deepening of the zones between them gives rise to sulcate types." Parker and Jones (1865) went so far as to suggest that *Lagena sulcata* (Walker and Jacob) should be considered the central species around which all others of this genus exist as varietal modifications! From these comments, it can be seen that distinguishing the one species from the other is a difficult matter. The author usually distinguishes the present species by its more numerous, finer costae and prominent apertural neck. Rare.

Subfamily NODOSARIINAE

Genus *Lenticulina* Lamarck, 1804

Cushman (1948) states that "in many species, it is very difficult to separate *Robulus* from *Lenticulina*, and it may be best, as a practical matter, to drop *Robulus* and use *Lenticulina* for both." This has been done by the present author.

Lenticulina limbosa (Reuss)

Plate 1, figures 24-25

Cristellaria (Robulina) limbosa REUSS, 1863, Sitzb. Akad. Wiss. Wien, vol. 48, p. 55, pl. 6, fig. 69.

Lenticulina limbosa (Reuss). — BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 147.

In the author's opinion, the present species has frequently been recorded under the name "*cultrata*," which appears to have been the usual designation applied during the Nineteenth Century to forms with thin, well developed keels. The nature of *Lenticulina cultrata* (Montfort) is indeterminate because of the unreliability of the type figure and the unavailability of the holotype. Frequent.

Lenticulina rotulata (Lamarck)

Lenticulites rotulata LAMARCK, 1804, Ann. Mus., vol. 5, p. 188; 1806, *ibid.*, vol. 8, pl. 62, fig. 11.

Lenticulina rotulata (Lamarck). — CUSHMAN, 1927, Contr. Cushman Lab. Foram. Res., vol. 3, p. 124, pl. 28, fig. 7.

The first record of this species was made in the "velins" of the Paris Museum (1802); Lamarck later published a figure and description (1804, 1806). The specimens he examined were obtained from Meudon, near Paris, and their geologic age is in doubt, some authors, e.g., Glaessner (1945), placing them in the Upper Cretaceous, others, e.g., Cushman (1927), placing them in the Eocene. A further difficulty is that the type figure and description are both inaccurate and inadequate for identification purposes. Cushman refigured the type specimen in 1927, and the present specimens agree closely with his illustration. Frequent. It also occurs in large numbers in the London Clay.

Lenticulina umbonata (Reuss)

Plate 1, figure 29

Robulina umbonata REUSS, 1851, Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 68, pl. 4, fig. 24.

Lenticulina umbonata (Reuss). — BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 148.

Lenticulina trigonostoma (Reuss) differs from the present species in having less prominent umbonal areas, more chambers in the ultimate whorl, and a more pronounced keel. Rare. Sixteen species of the genus *Lenticulina* were recorded from the London Clay (Bowen, 1954).

Genus *Glandulina* d'Orbigny, 1839

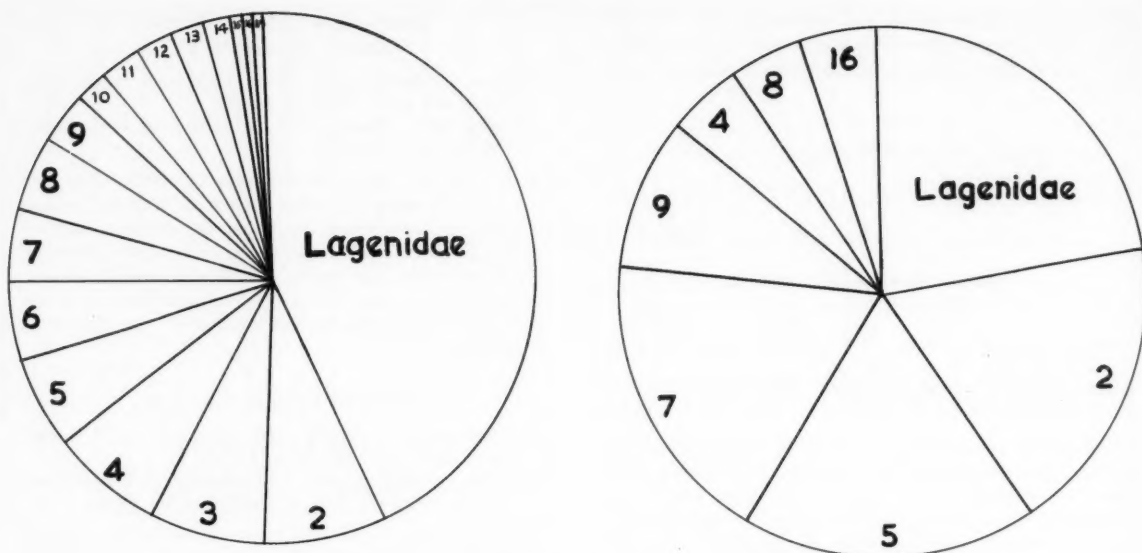
Glandulina laevigata (d'Orbigny)

Plate 1, figure 26

Nodosaria (Glandulina) laevigata D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 252, pl. 10, figs. 1-3.

Pseudoglandulina laevigata (d'Orbigny). — CUSHMAN AND STAINFORTH, 1951, Jour. Pal., vol. 25, p. 147, pl. 26, fig. 6. — BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 156.

The similar species *Pseudoglandulina turbinata* Detling, 1946, can be distinguished from the present one by its fewer chambers and entosolenian tube. Frequent.



TEXT-FIGURE 2

Diagrams showing the relative proportions of the foraminiferal families recorded from the London Clay (Lower Eocene) and the Bartonian (Upper Eocene). In both cases, the Lagenidae predominate. The key to the other families is as follows: 2 = Anomaliniidae; 3 = Rotaliidae; 4 = Buliminidae; 5 = Nonionidae; 6 = Textulariidae; 7 = Miliolidae; 8 = Chilostomellidae; 9 = Polymorphinidae; 10 = Globigerinidae; 11 = Verneulinidae; 12 = Ammodiscidae; 13 = Heterohelicidae; 14 = Ophthalmitidae; 15 = Globorotaliidae; 16 = Lituolidae; 17 = Valvulinidae.

Family LITUOLIDAE

Subfamily HAPLOPHRAGMIINAE

Genus AMMOBACULITES Cushman, 1910

Ammobaculites agglutinans (d'Orbigny)

Spirolina agglutinans D'ORBIGNY, 1846, Foram. Foss. Bassin Tert. Vienne, p. 137, pl. 7, figs. 10-12.

Ammobaculites agglutinans (d'Orbigny). — CUSHMAN, 1910, U. S. Nat. Mus., Bull., no. 71, pt. 1, p. 115, text-fig. 176.

Although this species has been recorded from pre-Eocene beds, e.g., by Khan (1950) from the Gault of Kent, England, these records are spurious. It is not present in the London Clay, and it appears to have originated somewhere in mid-Eocene time. Rare.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina akneriana d'Orbigny

Quinqueloculina akneriana D'ORBIGNY, 1846, Foram. Foss. Bassin Tert. Vienne, p. 290, pl. 18, figs. 16-21.

The author is in agreement with the view expressed by Marks (1951) that "most of the modern authors have made [this species] a synonym of *Quinqueloculina semi-*

nulum (Linné), but as Thalmann has pointed out, Linnæus never published an adequate figure for the recognition of the species." There can be no doubt that the species has been described under many different names, and the synonymy is given by Bowen (1954a). Frequent. Present in the London Clay. It was recorded from the Oligocene by Bhatia (1955) under the name *Quinqueloculina seminulum* (Linné).

Quinqueloculina bicarinata d'Orbigny

Quinqueloculina bicarinata D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 302, no. 35.

Although recorded as Oligocene and Pliocene to Recent by Bhatia (1955), this species occurs in the Bartonian, but not in the London Clay. Rare.

Quinqueloculina impressa Reuss var. *cognata* Bornemann

Quinqueloculina cognata BORNEMANN, 1855, Zeitschr. Deutsch. Geol. Ges., vol. 7, no. 2, p. 350, pl. 9, fig. 7.

Quinqueloculina impressa Reuss var. *cognata* Bornemann. — HAGN AND HOLZL, 1952, Geologica Bavarica, no. 10, p. 87.

Upper Eocene to Oligocene in range. Rare.

BARTONIAN SMALLER FORAMINIFERA

Quinqueloculina juleana d'Orbigny

Plate 1, figures 18–19

Quinqueloculina juleana D'ORBIGNY, 1846, Foram. Foss. Bass. Tert. Vienne, p. 298, pl. 20, figs. 1–3.

Considerable morphological variation is found in this species. Bhatia (1955) illustrates this and discusses the synonymy. Rare.

Family NONIONIDAE

Genus **ELPHIDIUM** Montfort, 1808

Elphidium minutum (Reuss)

Polystomella minuta REUSS, 1865, Sitzb. Akad. Wiss. Wien, vol. 50, pt. 1, p. 478, pl. 4, fig. 6.

Elphidium minutum (Reuss). – CUSHMAN, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 40, pl. 10, figs. 22–25.

The range of this species is Upper Eocene to Miocene. Rare.

Genus **NONION** Montfort, 1808

Nonion depressulum (Walker and Jacob)

Plate 1, figures 20–21

Nautilus depressulus WALKER AND JACOB, 1798, Adam's Essays, p. 641, pl. 14, fig. 33.

Nonion depressula (Walker and Jacob). – BOWEN, 1954, Ann. Mag. Nat. Hist., ser. 12, vol. 7, p. 745, text-fig. 2, nos. 1–2.

This species has a wide bathymetric range and can colonise brackish water. It was recorded from the Oligocene by Bhatia (1955) and does not occur in the London Clay. Its range is Upper Eocene to Recent. Frequent.

Nonion scaphum (Fichtel and Moll)

Plate 1, figures 27–28

Nautilus scapha FICHTEL AND MOLL, 1798, Test. Micr., p. 105, pl. 19, figs. d–f.

Nonion scaphum (Fichtel and Moll). – BOWEN, 1954, Ann. Mag. Nat. Hist., ser. 12, vol. 7, p. 747, text-fig. 1, nos. 3–4.

An abundant arctic species at the present time (see Bowen, 1954b), and one favouring a shallow-water habitat. The range is Eocene to Recent. Rare.

Nonion umbilicatum (Montagu)

Plate 1, figures 22–23

Nautilus umbilicatus MONTAGU, 1803, Test. Brit., p. 191.

Nonion umbilicatus (Montagu). – BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 160, text-fig. C (4–6).

Nonion pompilioides (Fichtel and Moll) resembles the present species, and Macfadyen (1930) recorded specimens "agreeing with d'Orbigny's form *Nonion soldanii*," which he regarded as transition forms between the two. Marks (1951) placed *Nonion umbilicatum* in synonymy with *Nonion pompilioides*, but referred to no intermediate

forms. As no such forms have been found in the London Clay or the Bartonian, and since *Nonion pompilioides* is much broader in apertural view, with fewer chambers in the last whorl than the present species, the author regards them as separate species.

Heron-Allen and Earland (1932) distinguish their species *Anomalina umbilicatulula* from this one by the size of its umbilical recess. In the opinion of the author, there is no difference between them, and Heron-Allen and Earland's species should properly be regarded as synonymous with *Nonion umbilicatum*. It may be added that, even if this morphological difference were admissible as a significant specific character, there would be absolutely no justification for removing this group of forms to a new foraminiferal family. Rare.

Family POLYMORPHINIDAE

Subfamily POLYMORPHININAE

Genus **GLOBULINA** d'Orbigny, 1839

Globulina gibba (d'Orbigny)

Plate 1, figure 13

Polymorphina (*Globulina*) *gibba* D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 266, no. 10; Modèles, no. 63.

Globulina gibba (d'Orbigny). – BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 163.

The terminal end of the test shows much individual variation in this species. In some specimens it is pro tuberant, in other it is rounded, with the aperture flush with the surface of the test. Rare.

Genus **PYRULINA** d'Orbigny, 1839

Pyrulina gutta (d'Orbigny)

Plate 1, figure 11

Polymorphina (*Pyruline*) *gutta* D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 267, pl. 12, figs. 5–6.

Pyrulina gutta (d'Orbigny). – BOWEN, 1954, Proc. Geol. Assoc., vol. 65, pt. 2, p. 163.

Very rare, both here and in the London Clay.

FAUNAL ANALYSIS

The marine Bartonian beds of Barton, Hampshire, do not contain many foraminifera, the total number of species found in them being much smaller than the yield from the London Clay recorded by Bowen (1954a) and from the Oligocene of the Isle of Wight recorded by Bhatia (1955). The comparative figures are: London Clay, 136; Oligocene, 62; and Bartonian, 22. The relative distributions of the various foraminiferal families represented are shown in text-figure 2.

As in the London Clay, the majority of specimens were derived from the clay bands, and the sands show a relative paucity. The whole faunule is of a transitional

nature, some of the species being reminiscent of the Lower Eocene, others foreshadowing the conditions and faunas of the Oligocene. The diminution in numbers, both of individuals and species, can no doubt be accounted for by this fact. Conditions were highly variable, and in latest Bartonian time the waters were becoming progressively less saline.

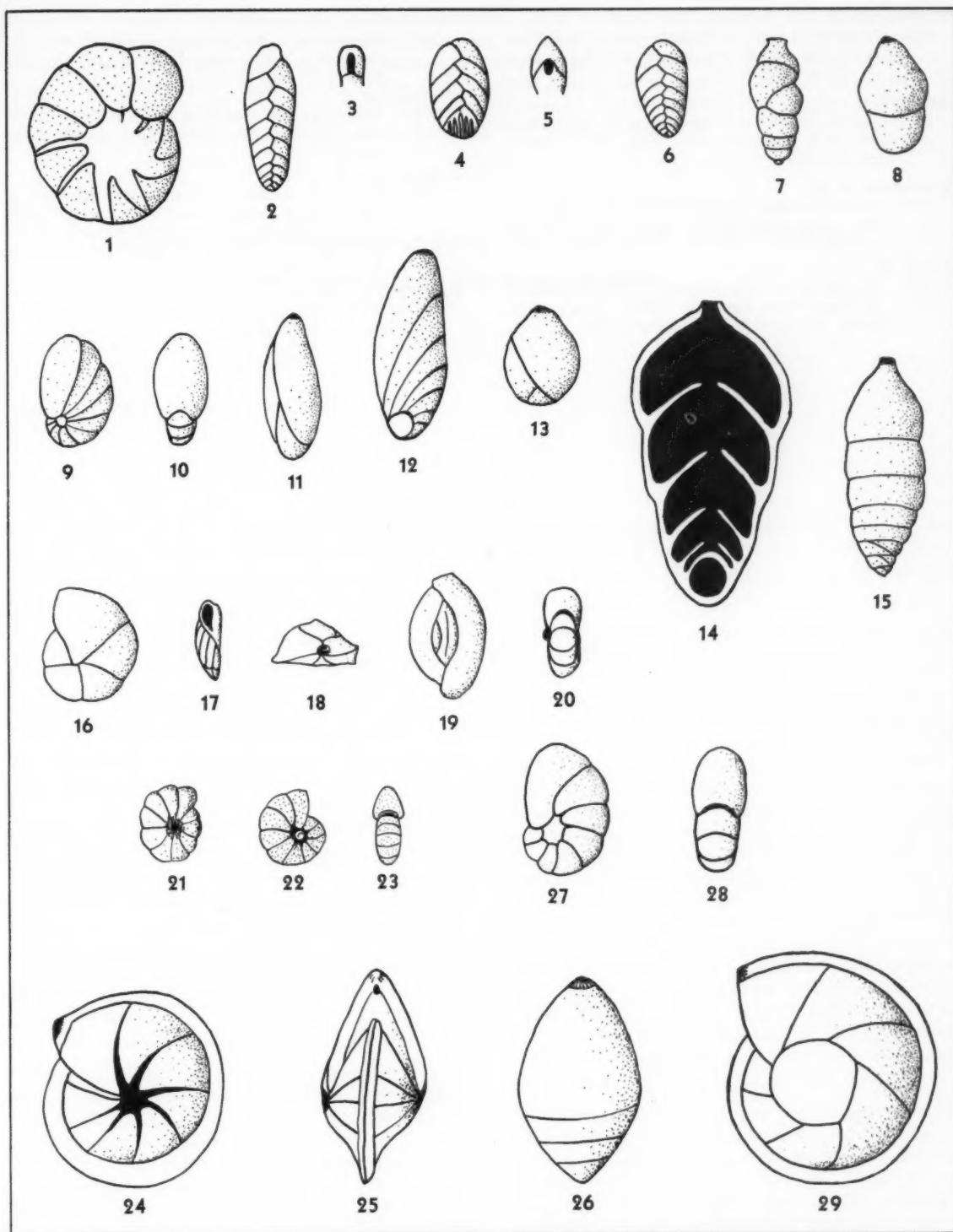
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PLATE I

The species illustrated in figures 2-10, 12, and 14-15 occur in the London Clay but not in the Bartonian. The species illustrated in figures 1, 11, 13, 16, 22-29 are present in both formations.

- | | |
|--|--|
| 1 <i>Cibicides vulgaris</i> (Plummer)
Ventral view. \times ca. 63. | show that the test is composed of uniserially arranged, embracing chambers. \times ca. 63. |
| 2-3 <i>Bolivina punctata</i> d'Orbigny
Plan and apertural views. \times ca. 63. | 15 <i>Glandulina conica</i> Neugeboren
Side view of microspheric specimen. \times ca. 63. |
| 4-5 <i>Bolivina moodyensis</i> Cushman and Todd
Plan and apertural views. \times ca. 63. | 16 <i>Pullenia quinqueloba</i> (Reuss)
Side view. \times ca. 63. |
| 6 <i>Bolivina advena</i> Cushman
Plan view. \times ca. 63. | 17 <i>Buliminella elegantissima</i> (d'Orbigny)
Plan view. \times ca. 63. |
| 7 <i>Uvigerina aculeata</i> d'Orbigny var. <i>asperula</i> Czjzek
Side view. \times ca. 63. | 18-19 <i>Quinqueloculina juleana</i> d'Orbigny
Apertural and plan views. \times 30. |
| 8 <i>Pseudoglandulina obtusissima</i> (Reuss)
Side view. \times ca. 63. | 20-21 <i>Nonion depressulum</i> (Walker and Jacob)
Apertural and side views. \times 50. |
| 9-10 <i>Nonion elongatum</i> (d'Orbigny)
Side and apertural views. \times 90. | 22-23 <i>Nonion umbilicatum</i> (Walker and Jacob)
Side and apertural views. \times ca. 63. |
| 11 <i>Pyrulina gutta</i> (d'Orbigny)
Side view. \times ca. 63. | 24-25 <i>Lenticulina limboza</i> (Reuss)
Side and apertural views. \times ca. 43. |
| 12 <i>Marginulina crepidula</i> (Fichtel and Moll)
Side view. \times 90. | 26 <i>Glandulina laevigata</i> (d'Orbigny)
Side view. \times ca. 63. |
| 13 <i>Globulina gibba</i> (d'Orbigny)
Side view. \times ca. 63. | 27-28 <i>Nonion scaphum</i> (Fichtel and Moll)
Side and apertural views. \times 90. |
| 14 <i>Pseudoglandulina ovata</i> (Cushman and Applin)
Section through megalospheric specimen to | 29 <i>Lenticulina umbonata</i> (Reuss)
Side view. \times ca. 43. |



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ABSTRACT: Grayson (1956) believes that the artificial conversion of calcite to fluorite explains the presence of "microforaminifera" in standard acid preparations. In reality, the natural resistance of many minute structures in samples of various sediments is very great. "Microforaminifera" are recognizable even after natural decalcification, when they possess membranous linings or when their chamber walls have been replaced with resistant mineral matter at an early stage of sedimentation. In addition, the microfossils commonly associated with them are not "polospores" (Grayson, 1956), but various flagellate Protista, preserved because of the characteristic organic material of which their tests are composed.

Fossil "microforaminifera" in various sediments and their reaction to acid treatment

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The present note is a reponse to the article by Grayson (1956) entitled "The conversion of calcite to fluorite." In that article, Grayson states that the shells and tests of calcite-producing organisms were not destroyed by "the standard hydrofluoric acid treatment for the removal of the siliceous matter," and also that no reaction occurred when the remains were subsequently treated with hydrochloric acid. X-ray analysis "showed that the shellfragments were no longer composed of calcium carbonate, but were now composed of calcium fluoride." Grayson presents figures illustrating the excellent preservation of the various shells examined to confirm the first results in the residues from the standard treatment.

The successful application of his method to the tests of foraminifera such as *Globigerina* sp., and the knowledge that hydrochloric acid used alone and applied directly to normal shells of foraminifera dissolves the calcite completely, caused Grayson to criticize strongly the interpretations proposed by Wilson and Hoffmeister (1952) and by Hoffmeister (1955) to explain the presence of "microforaminifera" in hydrochloric and hydrofluoric acid preparations.

Grayson considers most of the "specimens of foraminifera from Tertiary shales" illustrated by Wilson and Hoffmeister (1952, text-figs. 1-20 or 21) as products of the conversion of calcite to fluorite during "the standard hydrofluoric acid treatment." Two of their microfossils (Wilson and Hoffmeister, 1952, text-figs. 22 and 23), however, are believed by Grayson to be "fungal in origin rather than

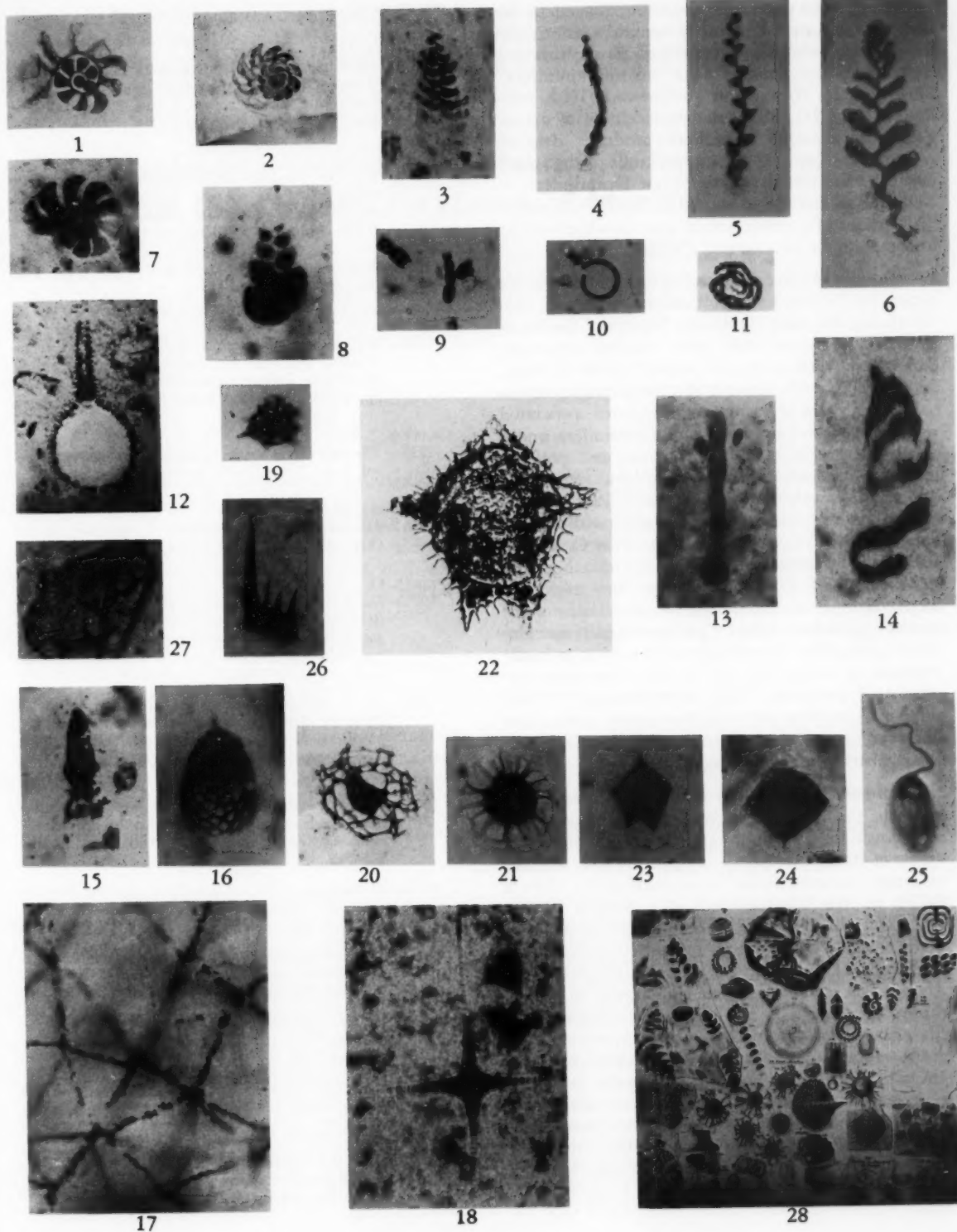
"microforaminifera," and similar to some microfossils extracted by Grayson from Cretaceous sediments (Grayson, 1956, p. 72, text-fig. 1, consisting of three figures).

Both sets of figures, Wilson and Hoffmeister's text-figures 22 and 23 (1952) perhaps more clearly than some parts of Grayson's text-figure 1 (1956), show small round bodies arranged according to size in a short and sometimes incomplete spiral series. This structure is similar to that of the first-formed chambers of a number of foraminiferal species (*Rotaliidae* and others). The resistance of such membranous forms, which can be isolated from the enclosing sediments by acid treatment, is natural and requires no artificial conversion; it is a result of the fact that the inner coats of the individual chambers are composed of an organic chitin-like material. The occurrence of these spiral foraminiferal linings and of similar rectilinear chains of linings is not rare; they have been observed in various sediments and their residues by various authors since the days of Ehrenberg (1838, 1854). Eisenack (1954) recently published a brief bibliography of these microfossils. In the present note, I have assembled a few examples illustrating them (see also Wetzels, 1933a, b; 1948; 1951a, b).

In addition to the membranous linings, there are other factors that may explain why these small chambers are recognizable in samples of sediments or their residues in spite of natural (not always complete) decalcification. One factor is pseudomorphous transformation of the microfossils, whose

PLATE 1

- 1-2 Membrane-like molds of foraminifera (cf. Rotaliidae)
1, hydrochloric acid residue from Cretaceous chalk, Holstein; $\times 60$. 2, erratic flint, Holstein; $\times 75$.
- 3-6 Membrane-like molds of foraminifera (cf. Textulariidae, etc.)
3, Cretaceous flint, Rügen; $\times 80$. 4, erratic flint, Holstein; $\times 105$. 5, hydrochloric acid residue from Cretaceous chalk, Holstein; $\times 85$. 6, hydrochloric acid residue from Cretaceous chalk, Holstein; $\times 100$.
- 7-8 Pyritized molds of foraminifera
7, resembling Rotaliidae; erratic flint, Holstein; $\times 60$. 8, resembling Textulariidae; Cretaceous flint, Lüneburg, Germany; $\times 150$.
- 9-11 Pyritized molds (fragments) of foraminifera
Hydrochloric acid residues, lower part of the Middle Triassic, Weser area, Germany. 9, resembling *Nodosaria*(?); $\times 55$. 10-11, resembling *Ammodiscus*(?); $\times 45$.
- 12 Peripheral pyritization in *Lagena* cf. *hispida* Reuss
Erratic flint, Holstein; $\times 50$.
- 13-14 Membrane-like, partly pyritized molds of foraminifera(?)
13, resembling *Nodosaria*(?); Danian flint, Sweden; $\times 45$. 14, resembling *Saracenaria*(?); erratic flint, Holstein; $\times 120$.
- 15-16 Pyritized skeletons of Radiolaria
15, *Dictyomitra* sp. indet.; erratic flint, Holstein; $\times 150$. 16, *Theosyringium*? sp. indet.; erratic flint, Holstein; $\times 200$.
- 17 Pyritized mold of sponge skeleton
Erratic flint, Holstein; $\times 80$.
- 18 Rhythmical precipitate within a cruciform sponge spicule, partly pyritized or siliceous(?). Erratic flint, Holstein; $\times 100$.
- 19-20 Radiolaria-like girder structures, related to Hystrichosphaeridea
19, new genus, new species; flint flake, Moens Klint, Denmark; $\times 70$. 20, *Cannosphaeropsis utinensis* Wetzel; erratic flint, Holstein; $\times 140$.
- 21 Egg-like spinose body ("spined shell"); not a "polospore," but a marine protistan, *Hystrichosphaera furcata* (Ehrenberg)
Erratic flint, Holstein; $\times 270$.
- 22 Armate spined body related to the Dinifera (Flagellata), *Wetzeliiella articulata* (Wetzel) Eisenack
Eocene clay, Holstein; $\times 260$.
- 23-24 Typical examples of fossil Dinifera (Flagellata)
23, (*Palaeo-*)*Peridinium* cf. *conicum* (Gran) Ostenfeld and Schmidt; erratic flint, Holstein; $\times 215$.
24, *Spongodinium delitiense* (Ehrenberg) Deflandre; Danian flint, Stevns Klint, Denmark; $\times 115$.
- 25 Peculiar organic body still bearing a flagellum thread, *Ophiobolus lapidaris* Wetzel (Flagellata)
Erratic flint, Schleswig-Holstein; $\times 645$.
- 26 Comb-shaped bristled fragment ("scolecodont"), the masticatory organ of an annelid
Erratic flint, Holstein; $\times 170$.
- 27 Fish scale(?) (fragment) with minute tubes of a boring organism
Erratic flint, Holstein; $\times 125$.
- 28 Reduced cut from plate 37 of Ehrenberg's "Mikrogeologie" (1854); see especially nos. VII and VIII: Foraminifera (molds), Peridinea, "Xanthidia" (Ehrenberg) = Hystrichosphaeridea, and other organisms.



cavities or walls were previously filled diagenetically with siliceous, pyritic or other mineral matter. This factor must also be remembered in considering the chemical composition of the "microforaminifera," illustrated by Wilson and Hoffmeister (1952, text-figs. 1-20 or 21). Molecular replacement of matter during fossilization sometimes produces detailed reproductions of many different kinds of organisms (see my examples illustrating these foraminifera, as well as Radiolaria and sponges). In 1953, I wrote: "All grades of transformation may be observed, up to complete metasomatism" (Wetzel, 1953b).

I would also like to call attention to a sentence in the paper by Wilson and Hoffmeister (1952, p. 26): "Probably the most significant feature of the fossils is their association with other minute structures, particularly with spores and pollen." In my opinion, and also in that of a number of other micropaleontologists, many of the minute structures associated with the resistant inner coats of foraminifera under discussion are in reality not "spores and pollen." Such "no-polospores" (compare the new term "polospores" proposed by Grayson, 1956, p. 71) have often been described, beginning with Ehrenberg (1838, 1854), and more recently by O. Wetzel (1953a, b), Eisenack (1954), and Deflandre and Cookson (1955). Most probably they represent flagellate algae similar to the dinoflagellates of the marine plankton. Other "problematica" are also found among the microfossils in flintstones, or in the residues of calcareous and argillaceous sediments after acid treatment. Even the occurrence of fossil fungae is possible; perhaps the minute tubes often observed traversing fragments of fish scales attest their existence as boring organisms.

In addition, it is possible that the chemicals (for example, the hydrochloric acid) used in isolating the microfossils may contain some membranous fragments of Recent fungal spores and the like, leading to erroneous conclusions in evaluating the objects found in the residues (see O. Wetzel, 1951a, pp. 108-109). The objects there described as enigmatic fossils were mounted in two preparations of Cretaceous samples, but are probably identical with *Myxotrichum chartarum*, which I have seen in preparation XXg of Dr. P. Michaelis, of Voldagsen über Elze, Hannover. Dr. Michaelis has sent me a photograph of such a fungal sporangium in his collection. In both cases, therefore, the enigmatic organism represents a fortuitous Recent contamination of a fossil preparation, and furthermore, the new name *Polycuppes dichothamnoides* Wetzel, 1951, which I proposed for my discovery, is not valid, but is a synonym of a Recent form.

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ABSTRACT: *Haplophragmoides coahuilaensis*, n. sp., is described from the lower Aurora limestone (Lower Cretaceous) of the Sierra de la Gavia, Coahuila, Mexico. This new species seems most closely related to *Haplophragmoides? barrowensis* Tappan, from the Lower Jurassic of Alaska, especially in the degree of evoluteness.

Haplophragmoides coahuilaensis, a new species from the Lower Cretaceous of Mexico

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INTRODUCTION

In December, 1954, the senior author collected samples of chert-bearing limestone from the lower part of the Aurora limestone on the south flank of the Sierra de la Gavia anticline, about 0.4 mile north of San Lazaro, on the Saltillo-Monclova highway, Coahuila, Mexico. The Aurora limestone is in contact with the La Peña formation at this locality.

Numerous specimens of a new species of *Haplophragmoides* were found in the insoluble residue when the limestone was dissolved in hydrochloric acid. One fragment of another foraminifer, probably a *Nodosaria*, was noted, along with three indeterminate smooth-valved ostracodes. This paper concerns itself only with the description of the new species of *Haplophragmoides*.

The authors wish to thank the following persons for their help: Dr. Helen Tappan Loeblich, for her courtesy in permitting the loan of paratypes of her species *Haplophragmoides? barrowensis*; M. A. Peterson, of the Union Producing Company, who made the collecting trip possible; and H. O. Wiseman, of the Union Producing Company, who made the photomicrographs from which some of the figures were drawn.

SYSTEMATIC DESCRIPTION

Order FORAMINIFERA

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

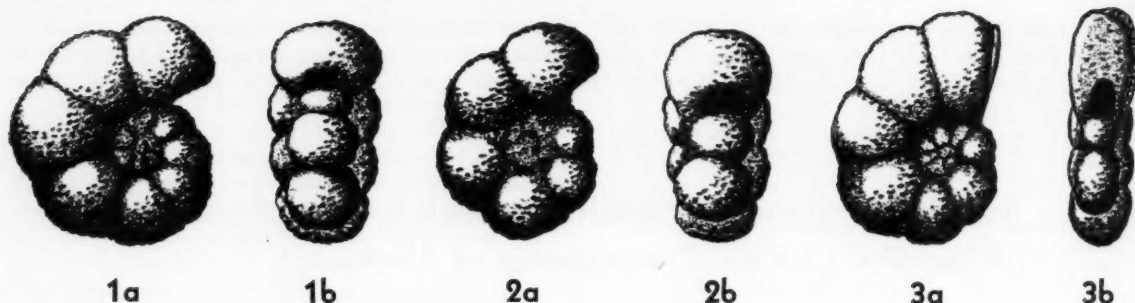
Haplophragmoides coahuilaensis Conkin and Conkin, new species

Text-figures 1-3

Description: Test free, planispiral, minutely to slightly involute, consisting of a proloculus and two to two and one-quarter whorls, divided into chambers; periphery broadly rounded; total number of chambers nine to fourteen, with five to eight and one-half chambers in the outer whorl; most of the mature specimens have a total of twelve or thirteen chambers, with six to eight chambers in the outer whorl; chambers increase gradually in size, becoming quite large and inflated in the outer whorl, giving many specimens an inflated, elongate appearance, as seen in text-figures 2a and 3a; sutures radial and nearly straight, fairly distinct in the outer whorl; the proloculus and inner chambers usually indistinct, as in text-figure 2a, but can be seen when specimen is wet, as in text-figures 1a and 3a; aperture an arch, usually wider than high, at base of apertural

TABLE 1
MEASUREMENTS, IN MILLIMETERS

	Greatest diam- eter	Greatest thick- ness	Height of aper- ture	Width of aper- ture
Holotype (text-fig. 1) (largest specimen)	0.372	0.173	0.040	0.079
Paratype (text-fig. 2)	0.306	0.173	0.040	0.066
Paratype (text-fig. 3)	0.372	0.133	0.065	0.046
Smallest specimen	0.212	0.119	0.026	0.027
Average of 21 speci- mens, including the four above	0.301	0.166	0.032	0.052



TEXT-FIGURES 1-3

Haplophragmoides coahuilaensis Conkin and Conkin, n. sp. 1a-b, holotype (U.S.N.M. no. P5358), as seen when wet. 2a-b, paratype (U.S.N.M. no. P5359). 3a-b, paratype (U.S.N.M. no. P5360), as seen when wet; last chamber broken off, revealing wall between it and preceding chamber; this specimen may be somewhat flattened. All figures approximately $\times 100$.

face of last chamber; in some specimens the aperture is higher than wide, or approximately equally as high as wide; wall arenaceous, with medium-sized grains of quartz sand in a fine groundmass of silica; surface of wall moderately rough; measurements listed in Table 1.

Remarks: *Haplophragmoides coahuilaensis* seems to have closest affinities to *Haplophragmoides? barrowensis* Tappan (1951), from the Lower Jurassic (Pliensbachian) Kingah formation of northern Alaska, especially in the degree of evoluteness. A comparison between these two species is given in Table 2.

TABLE 2

COMPARISON OF *HAPLOPHRAGMOIDES? BARROWENSIS* TAPPAN AND *HAPLOPHRAGMOIDES COAHUILAENSIS*, N. SP.

Characters	<i>H.? barrowensis</i>	<i>H. coahuilaensis</i>
Number of chambers	19 in figure of holotype	9 to 14
Number of chambers in outer whorl	8 to 12	5 to 8½
Number of whorls	usually 2½	2 to 2½
Shape of test	discoidal	bulbous
Coiling	evolute	minutely to slightly involute
Wall	large grains, rough texture	medium grains, moderately rough texture
Aperture	obscure, but apparently at base of last chamber	broad or high arch at base of last chamber
Greatest diameter	1.04 mm.	0.372 mm.
Greatest thickness	0.26 mm.	0.173 mm.

Haplophragmoides coahuilaensis is regarded as specifically distinct from *Haplophragmoides? barrowensis* in that *Haplophragmoides coahuilaensis* has inflated chambers and a

smaller number of chambers per whorl. The degree of roughness and the size of the test are not regarded as of primary value in the differentiation of species.

Depositories of types: The holotype and two figured paratypes are deposited in the United States National Museum, Washington, D. C.; no. P5358 and nos. P5359 and P5360, respectively. Three unfigured paratypes are also deposited in each of the following institutions:

Department of Micropaleontology, American Museum of Natural History, New York; no. FT-1180.

Museum of Geology, University of Cincinnati, Ohio; nos. 32343, 32344, and 32345.

Department of Geology, University of Iowa, Iowa City, Iowa; no. 8296.

Museum of Paleontology, University of Michigan, Ann Arbor, Michigan; no. 33728.

Bureau of Economic Geology, University of Texas, Austin, Texas; no. 20268.

United States National Museum, Washington, D. C.; no. P5361.

Department of Micropaleontology, British Museum (Natural History), London; nos. P.43325, P.43326, and P.43327.

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Geologisches und Paläontologisches Institut, University of Tübingen, Germany; nos. Pr.1103/1-3.

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ABSTRACT: Pollen may be recovered from many types of inorganic sediments by the use of oil as a floating agent. Any size sample may be used. The pollen is highly concentrated in the final residue.

An oil-flotation method for the recovery of pollen from inorganic sediments

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INTRODUCTION

Pollen analysis has been concerned largely with peat bogs, but very recently, attention has turned to the analysis of soils from dry stream-banks, cave deposits, rock shelters, ancient lake beds, and similar inorganic deposits. Such soil material usually has a much lower pollen frequency than that of peat, and therefore samples as large as 100 grams have been used by some workers. A number of methods have been used for the recovery of pollen from large samples of inorganic sediments, including digestion with hydrofluoric acid or flotation with a solvent of high specific gravity. The oil-flotation method described in this paper is unique in that a solvent having a specific gravity less than one is used as a "carrier" to float the pollen to the surface of a water suspension of the sample. The method was adapted from the one used by Ledingham and Chinn (1955) to recover fungal spores from farm soils.

Several variations of the procedure presented below have been tested, including pretreatment with hydrofluoric acid, variation of the volume of oil used, and variation of the number of oil treatments, but only the most successful steps have been included. The procedure may readily be adapted to larger or smaller samples.

Contamination of the sample should be avoided at all times, and all sample containers should be kept covered. Inexpensive, unbreakable, and corrosion-resistant plates for use in covering containers may be made from heavy cardboard coated with Tygon paint.

METHOD

- 1) Slowly add conc. HCl to 100 g. soil until evolution of CO₂ ceases.

- 2) Adjust to pH 8 to 9 with NaOH.
- 3) Transfer the residue and liquid to a 1-liter cylinder. Bring the volume up to about 800 ml. with distilled water, and add 15 ml. white, light, U.S.P. paraffin oil (Central Scientific Co., Chicago, Ill.). Shake the cylinder and contents vigorously, end to end. Allow to stand until the phases separate.
- 4) Remove the oil phase with a pipette and transfer it to Whatman No. 1 filter paper in a 6-inch funnel.
- 5) Carry out steps 3 and 4 five more times, using fresh portions of oil. Bring the volume in the cylinder again up to 800 ml. with water as needed. Filter all the oil layers through the same piece of filter paper and discard the filtrates. It may be necessary to add a small amount of acetone and xylene to the contents of the funnel in order to hasten filtration. After removal of the sixth oil treatment, do not add any more oil to the cylinder, but shake the cylinder a seventh time and allow to stand. Transfer any residual oil phase to the funnel, and discard the contents of the cylinder.
- 6) Wash the oily residue, while still on the paper in the funnel, with two or three 20 to 30 ml. portions of acetone. Then wash the residue with two or three 20 to 30 ml. portions of xylene. Continue washing with alternate portions of acetone and xylene until the residue and paper are largely free of oil. Then completely dehydrate the filter paper and residue with several portions of acetone.

- 7) Transfer the dehydrated paper and residue to a copper beaker, and add 30 to 50 ml. 48% HF. Bring the mixture almost to boiling for 10 minutes, or let stand overnight. Allow to cool and centrifuge in polyethylene tubes. After centrifugation, pour the supernatant liquid onto a piece of Whatman No. 1 filter paper in a 6-inch funnel. Also add about 100 ml. water to the contents of the funnel to dilute the HF.

All the supernatants, after centrifugation during steps 8 to 17, must be filtered through the same paper as was used in step 7.

- 8) Return the residue from the centrifuge tube to a copper beaker and repeatedly digest the residue with HF as described in step 7, until the sample is completely digested.
- 9) Wash the digested residue with warm 5N HCl, centrifuge, and decant into the funnel.
- 10) By means of several volumes of 10% NaOH, transfer the residue to a beaker and place in a boiling-water bath for 20 minutes. Centrifuge and decant.
- 11) Wash the residue with water, centrifuge, and decant.
- 12) Wash the residue with glacial acetic acid, centrifuge, and decant.
- 13) Acetolyze the residue with 50 ml. acetolysis mixture, which contains 9 parts acetic anhydride to 1 part conc. H_2SO_4 (Erdtman, 1954), for 15 minutes in a boiling-water bath. Centrifuge in a glass tube. Dilute the supernatant liquid with several volumes of water before adding it to the funnel, so that it will not digest the filter paper used to filter the supernatants.
- 14) Wash the residue with glacial acetic acid, centrifuge, and decant.
- 15) To the residue add two or three times its volume of 10% NaOH, and heat in a boiling-water bath for 20 minutes. Centrifuge and decant.
- 16) Wash the residue with water, centrifuge, and decant. Repeat.
- 17) Wash the residue with acetone, centrifuge, and decant. Repeat.
- 18) The residue from step 17 may now be mounted in glycerine jelly stained with basic fuchsin (Wodehouse, 1935), or it may be combined with the residue obtained in step 19.

- 19) The filter paper which was first used in step 7, and which was also used to filter all the supernatants from steps 7 to 17, is now thoroughly freed of all oil and water by means of several rinses with acetone and xylene while the residue is still in the funnel (as in step 6). After the paper and residue have been completely freed of oil and are dehydrated, they are treated according to steps 12 to 17, except that all supernatants following the centrifugations are discarded.

- 20) The residue obtained in step 19 may be mounted separately or combined, before mounting, with the residue obtained in step 18.

DISCUSSION

Ledingham and Chinn (1955) present data indicating that up to 75 per cent of the spores present in a soil are recovered by the oil-flotation method. Based upon experiments with cave deposits, at least 90 per cent of the pollen is recovered by our modified and more exhaustive procedure. Furthermore, in comparison with samples prepared by the conventional hydrofluoric acid method (Erdtman, 1954), the final residue obtained by the oil-flotation method contained up to 100 times more pollen per unit volume of residue. In practical terms, this means a great saving in the number of slides prepared and in the time spent in examination of slides.

The method appears to be applicable to many types of inorganic sediments, excellent results having been obtained with sediments from unconsolidated cave deposits, a wet stream-bed, a dry stream-bank, and rock shelters in Illinois and Colorado. Although the procedure is rather long, a large number of samples may be carried through steps 1 to 6 simultaneously. Exclusive of labor, the cost per sample is quite low, and the solvents used are all inexpensive, so that it is not necessary to recover them for re-use.

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ABSTRACT: Study of planktonic foraminifera from an Equatorial Pacific core dated by Hough and Urry as Pleistocene reveals typical modern warm-water species from top to bottom. Certain species show unusual resistance to disintegration and dissolution. It is believed that tests on the bottom truly reflect surface-water temperatures. Modern planktonic foraminifera date mostly from the pre-Pleistocene, and thus lived through the ice ages, but warm-water forms were restricted to areas near the equator during these times. The evidence tends to support Arrhenius' conclusions that there is little calcium carbonate accumulation at present, that the maximum accumulation occurred during the ice ages, and that the same warm-water faunas lived continuously near the equator throughout the Pleistocene.

Planktonic foraminifera from an Equatorial Pacific core

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INTRODUCTION

The core examined in this study was taken by J. L. Hough from the United States Coast Guard Cutter *Northwind* during "Operation Highjump," the U. S. Navy Antarctic Expedition of 1946-1947. The location of the core was lat. 8°56.2' S., long. 92°05.2' W., in the South Pacific; the depth was 3932 meters.

Two papers have been written on this core. Urry (1949) made age determinations on this and a number of other cores by the per cent of equilibrium method for uranium, ionium, and radium. The core (numbered N-1) was stated by Urry to represent more than half of all Pleistocene time at the locality of collection. Hough (1953) described the lithology of the core and correlated the alternating layers of *Globigerina* ooze and red clay, plus Urry's dates, with the glacial and interglacial stages of the Pleistocene. In correlating the lithology of the core with Pleistocene events, Hough made the basic assumptions that the red clay was deposited during periods of colder climate and that the *Globigerina* ooze can be attributed to periods of warmer climate. On the basis of these assumptions, Hough recognized the occurrence of the last three glacial stages, Wisconsin, Illinoian, and Kansan, together with the Recent, Sangamon, and Yarmouth interglacial stages.

Dr. Hough kindly furnished the writer with half of the core for foraminiferal studies. The core was sampled continuously from top to bottom (75 samples), the sampling being governed by changes

in lithology. Species counts were made of those adult specimens retained on a 100-mesh screen. The species were then statistically examined in relation to each other and to the number of specimens per gram of air-dried sediment.

The writer did much of the work at the Marine Foraminifera Laboratory of Scripps Institution of Oceanography, which has a large collection of planktonic foraminifera, to which the writer made frequent reference. The taxonomy follows that used by Phleger and Parker (1951) and by Phleger, Parker, and Peirson (1953).

When this study began, it was hoped that presumed glacial sediments in the core would have species indicative of cooler waters. This hope was not realized. In all samples, from top to bottom of the core, the species were warm-water indicators such as *Globorotalia menardii-tumida*, *Pulleniatina obliquiloculata*, and abundant *Globigerina eggeri*. Furthermore, after the work had been done on the foraminifera, the dating of this specific core by Urry (1949) was seriously questioned by Volchok and Kulp (1955, p. 156). Consequently, this report has been considerably condensed, although it was thought desirable to finish the report on the foraminifera of such a frequently discussed core.

ACKNOWLEDGMENTS

The writer appreciates the assistance of Dr. J. L. Hough, of the University of Illinois, who furnished the core studied in this note, together with all

pertinent information connected therewith. The writer also appreciates helpful suggestions from R. S. Dietz, H. W. Menard, George Shumway, R. F. Dill, F. B. Phleger, J. F. Peirson, F. L. Parker, G. Arrhenius, and G. Emiliani.

DATA ON THE FORAMINIFERA

General

Almost all of the species found in present-day low-latitude assemblages (Phleger, Parker, and Peirson, 1953, p. 71) were found in the more complete assemblages in this core. Where tropical planktonic assemblages are preserved intact in the Pacific, the species listed by Phleger, Parker, and Peirson are almost always represented. Where solution has taken place, and the preserved assemblage includes only the more resistant species, the remainder of the absent species can be inferred with some confidence (Phleger, oral communication). For example, in an assemblage comprising *Globorotalia menardii*, *Globorotalia tumida*, *Globigerina eggeri*, *Sphaeroidinella dehiscens*, and *Pulleniatina obliquiloculata*, it can be assumed that the other typically warm-water species were present in the living assemblage, but were disintegrated and dissolved away. In the core discussed in this paper, the typically tropical species were present in the well-preserved assemblages; in the less well-preserved assemblages, disintegration and dissolution had removed all but the more resistant species, especially in the red clay layers. The species preserved in the red clay after most of the assemblage had been removed were dominantly *Globorotalia menardii*, *Globorotalia tumida*, *Globigerina eggeri*, *Sphaeroidinella dehiscens*, and *Pulleniatina obliquiloculata*, the degree of resistance to disintegration and dissolution being apparently in the order stated. Thus there was no significant difference between the faunas of the red clay and of the *Globigerina* ooze; all were low-latitude warm-water faunas.

Globorotalia menardii-tumida

It was found, as previous workers have discovered, that *Globorotalia menardii* and *Globorotalia tumida* intergrade, and that even the most conscientious worker cannot always separate them for counting purposes. For this reason, and also so that the present investigation could be compared with the work of Arrhenius (1952) in the same general area, the two species were lumped in the species count.

Globorotalia menardii-tumida specimens were present in all but three of the seventy-five samples. In two of these, no planktonic foraminifera were preserved, and in one, only three specimens of *Globigerina eggeri* were left. *Globorotalia menardii-tumida* specimens were the

most resistant forms, and in the least well-preserved assemblages were represented by hundreds of small rims or keels.

It appears that *Globorotalia menardii-tumida* specimens are slightly more resistant than the species of *Globigerina* in this core. This conclusion is the same as that reached by Phleger, Parker, and Peirson (1953) in their study of Atlantic deep-sea cores. Arrhenius (1952), on the other hand, found that *Globigerina* species were the least affected.

Globigerina species

The second-best preserved species were those of *Globigerina*. Arrhenius (1952) lumped all species of *Globigerina* in his studies of the eastern Equatorial Pacific. Because the core discussed in this paper came from the same general area, the writer also lumped all species of *Globigerina* together for statistical purposes. In the present study the *Globigerina* species normally preserved in the sediments after disintegration and dissolution was *Globigerina eggeri* and variations around this form. In all but three of the seventy-five samples, *Globigerina* species were preserved; in two of these three, no planktonic forms remained.

A summary of the occurrence of the resistant planktonic species preserved when strong solution had taken place is as follows:

SPECIES	Present in whole assemblages (average %)	Preserved in strongly dissolved assemblages (average %)
<i>Globorotalia menardii-tumida</i>	38	44
<i>Globigerina</i> spp.	38	43
<i>Sphaeroidinella dehiscens</i>	7	10
<i>Pulleniatina obliquiloculata</i>	10	3

Benthonics

The benthonic species were considered as a group and not broken down by species. As noted by most writers on the subject, the benthonic foraminifera are well adjusted to the bottom environment, and their thick, compact wall structure is commonly preserved.

In relatively well-preserved assemblages, the benthonics averaged 16 per cent; in assemblages strongly attacked by disintegration and dissolution, the average per cent increased to 46. The relationship between the benthonics and the planktonics was examined statistically, and it was determined that as the number of planktonics increases so does the number of benthonics, but at a slower rate. Arrhenius (1952) found the same general relationship.

DISCUSSION OF RESULTS

The relationship between the living assemblages in the upper waters and the assemblages in deep-sea sediments depends in part on the rate of settling. Almost all writers on the subject believe that there is little lateral transport of settling tests in oceanic currents.

Jerlov (1953*a*) believes that deep circulation in the eastern Pacific is too slow to have any marked effect on relatively large-sized particles, which sink rapidly. The close relationship between surface currents and bottom sediments has been noted by most writers on the subject (Murray and Renard, 1891; Revelle, 1944; Arrhenius, 1952; Correns, 1939; Kane, 1953; Ericson, 1953; and Phleger, Parker, and Peirson, 1953). This relationship would still be true if dead tests were carried down-current far from the area in which they start to sink. Sverdrup, Johnson, and Fleming (1942), Jerlov (1953*a*), Keunen (1950), Correns (1939), Kane (1953), and others believe that the great drift currents are too shallow to markedly effect great distribution of settling tests. Data kindly furnished the writer by R. M. Lesser, oceanographer at the Navy Electronics Laboratory, show that in the Equatorial Counter Current at 125° W. long., about 55 per cent of the total volume of transport is in the upper 100 meters; 75 per cent is in the upper 200 meters; and 95 per cent is in the upper 500 meters. In the North Equatorial Current, at one locality, about 85 per cent of the total volume of transport occurs in the upper 500 meters; at 158° W. long., in the Counter Equatorial Current, about 60 per cent of the total volume of transport occurs in the upper 100 meters; 85 per cent in the upper 200 meters; and 95 per cent in the upper 500 meters. It appears from Lesser's data that, in the great currents of the eastern Equatorial Pacific, there is virtually no movement due to surface currents below 700 meters. Jerlov (1953*b*) also concluded that most of the transport is above 500 meters in the Equatorial Pacific currents.

Thus it appears that an abandoned test, or that of a dead planktonic foraminifer, will be transported laterally a relatively short distance until it falls through the first 500–700 meters and will then sink almost vertically to the bottom. The rate of sinking of dead tests will probably never be solved by other than inference, because of the virtual impossibility of duplicating conditions in the great, turbulent oceanic currents. The above conclusions on transport and probable fast sinking are borne out, however, by the close correlation between the surface temperature and living assemblages, on the one hand, and tests in the bottom sediments on the other

(Ovey, in Wiseman and Ovey, 1950; Ericson, 1953; Kane, 1953; Phleger, Parker, and Peirson, 1953; Emiliani, 1954).

Correlations between temperatures and species distribution for most of the planktonic species have been worked out on the basic assumption that the tests in the bottom sediments represent the living assemblages above. Recent important papers in the field of temperature correlations of foraminifera all agree that the faunas indicated in the core on which this study is based are representative of warm, low-latitude waters (Phleger, Parker, and Peirson, 1953; Kane, 1953; Emiliani, 1954; Ovey, in Wiseman and Ovey, 1950; Wiseman, 1954).

Although the age-dating of this core has been seriously questioned (Volchok and Kulp, 1955), it is probable that at least the late Pleistocene (Wisconsin) is represented. Arrhenius (1952) found the same warm-water fauna in the Pleistocene deposits of the same area. The temperatures indicated for the near-surface waters in the area during the Pleistocene (based on the foraminifera in the bottom deposits) are about 20° C. (Phleger, Parker, and Peirson, 1953; Kane, 1953; Emiliani, 1954). This is important confirmation of the idea that the ice-age equatorial climates were not as rigorous as some writers have supposed, and that the temperatures were such as to permit reef-coral growth.

Almost all of the modern planktonic foraminifera were in existence before the Pleistocene and thus lived through that epoch. The species now found in tropical waters therefore existed through all of the glacial ages. This is true also of genera and of many species of reef corals. The tropical species of planktonic foraminifera evidently found conditions tolerable during the ice age. The area where waters warm enough for survival were found must certainly have been the equatorial belt. One would expect, then, that the Pleistocene foraminifera near the equator would be the same tropical species as those found there at the present time.

The area of survival must have been restricted, but the location of the core discussed in this paper (about 9° S. lat.) places it within the probable restricted area.

Daly (1910, 1948) supposed that the open oceans were chilled during the Pleistocene to such an extent that reef corals were killed and that these reef builders found "asylum" in the warm Pleistocene waters of the Moluccan Seas from whence the coral larvae issued to repopulate the coral areas of the open oceans. This idea is an important part of his

"Glacial Control Theory" of the formation of coral atolls. Kuenen (1947), Umbgrove (1947), and Davis (1928), on the other hand, thought that the reef corals were merely restricted and that the margins of the zones were the only areas affected by cold waters. The evidence that warm-water planktonic species lived in the open ocean during the ice age thus confirms the idea of a relatively mild equatorial climate, and tends to refute Daly's proposal that the waters were cold enough to kill the corals.

There are four general ways in which foraminifera in bottom sediments can be used to study temperature fluctuations in surface waters. The first, and most frequently used, is the alternation of warm- and cold-water species. The second makes use of the basic assumption that the areal extent of red clay in glacial times was greater, and the extent of *Globigerina* ooze was less (Schott, 1939); in parts of the Indian Ocean the glacial extent of Antarctic bottom waters was greater, and red clay underlies the *Globigerina* ooze of the present time. The third method is to examine the probable rates of production of total fauna and individual species (Arrhenius, 1952). The fourth method is to examine the species by the oxygen-isotope method (Emiliani, 1954; Ericson, 1953).

All of the methods listed above are valid. As cold glacial-age water moved from the poles, its effect would be the restriction of living zones toward the equator and advancement of red clay along the bottom. Thus the red clay—*Globigerina* ooze method would be applicable in very high latitudes; in middle latitudes, warm-water species would alternate with cold-water species; in some equatorial areas, the cold-water species would not encroach, and warm-water species, although restricted, would be present throughout the Pleistocene. The latter case is apparently true in the eastern Equatorial Pacific.

Arrhenius (1952) correlated absolute age-determination by the radiocarbon-titanium method with accumulation, and concluded that during the glacial age the temperature of the deep water must have been decreased, so that the ability of the water to dissolve calcium was increased. In spite of this, however, the rate of accumulation of calcium carbonate during the ice age in the eastern Equatorial Pacific increased as a result of the increased production of calcium carbonate because of increased rate of upwelling (which produced nutrients for phytoplankton) in the equatorial current divergences. Arrhenius believed that the glacial climates were such as to increase the trade-wind speed and thus the current speed, which resulted in increased

rates of upwelling. Thus Arrhenius finds ice-age sediments (in the eastern Equatorial Pacific) to be marked by increased rates of production of calcium carbonate, which is directly opposed to some previous views that red clay (lacking in calcium carbonate) indicates ice-age sedimentation. As previously noted, both views may be correct; the currents, latitude, and factors in sedimentation in each area must be examined individually.

In the present study there is a definite maximum of accumulation (based on the number of planktonic foraminifera per gram of air-dried sediment) just below the red-clay surface of the core, and the present time is a time of little carbonate accumulation. This same general situation is found in the cores studied by Arrhenius from the same general area. The foraminifera of this core are all warm-water low-latitude forms, and do not show the alternations of warm-water faunas with cooler-water or cold-water faunas which might support Hough's interpretation of the core. It appears to the writer that the evidence tends to support Arrhenius' conclusions of little calcium carbonate accumulation at present, maxima of accumulation during the glacial ages, and the same warm-water faunas living continuously in the area during the Pleistocene.

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Microforaminifera

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During a palynological examination of Recent marine bottom-samples from Brunei Bay and off-shore Brunei State (South China Sea), numerous microforaminifera (the term is used in the sense of Hoffmeister and Wilson, 1952) were observed. Some examples are shown in the accompanying photomicrographs (text-figs. 1-4). The samples, highly calcareous clays and silts, were treated with hydrochloric acid to completion of reaction, prior to treatment with hydrofluoric acid, yet the tests still survived.

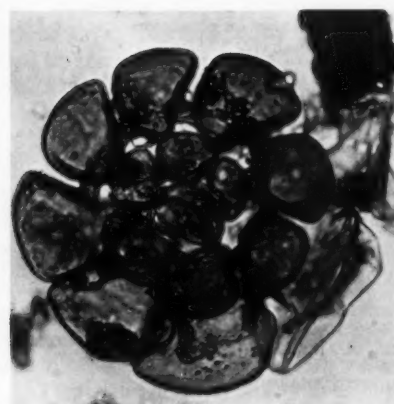
This is at variance with the suggestion of Grayson (1956, pp. 71, 72) that survival of the tests of calcareous microforaminifera is due to the conversion of the shells to fluorite during the initial treatment with hydrofluoric acid. If this assumption were valid, microforaminifera should not be present after treatment with hydrochloric acid prior to hydrofluoric acid. It appears, therefore, that, as Hoffmeister (1955) concluded, the survival of originally calcareous or arenaceous foraminifera is due to the presence of an acid-resistant (chitinous?) inner coat.

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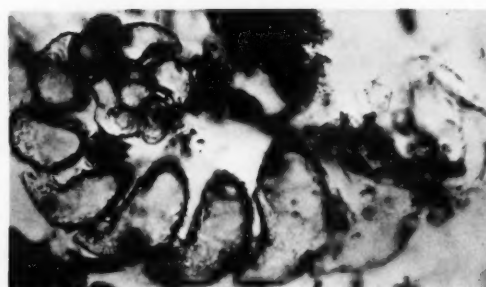
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TEXT-FIGURES 1-4

SPECIMENS OF MICROFORAMINIFERA, $\times 450$.



1



2



3



4

Orientation and binding power of Recent monothalamous foraminifera in soft sediments

KARL-GEORG NYHOLM

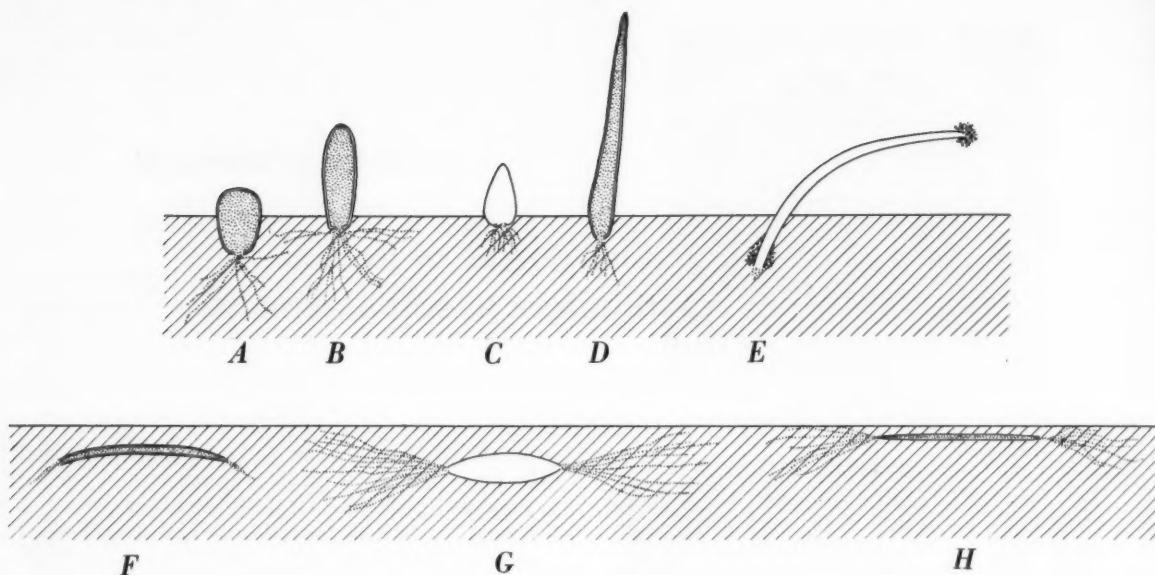
Zoologiska Institutionen
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The uppermost layers of soft marine sediments have a high detrital content. Although underlying beds also contain a high proportion of organic material, e.g., in the form of carotinoids, it is principally in the detrital layer that the Monothalamia obtain food by means of their pseudopodia. The variation in the type of pseudopodium is greater than that expressed by the terms *lobopodial*, *filopodial*, or *fili-reticulous*. Among other things, there is a characteristic difference in rigidity under culture conditions. The pseudopodial plasma of many *Gromia* types is more homogeneous and rigid than that of the genera *Hippocrepinella* and *Tinogullmia*, for example, in which the slender, fragile pseudopodial threads are scarcely able to secure a hold in the bottom sediment. In cultures, the former type of pseudopodia reach a greater depth than the latter, which assume a more superficial distribution. It seems likely that there is a similar differentiation in the natural environment. Ecologically, this means that different types bind the detritus at different levels in the sediment, and this must obviously be of considerable significance in the ecology of the microfauna, by increasing the resistance of the detrital layer to destruction, for example, by turbulence in the bottom water. It is interesting in this connection that the Monothalamia found on soft sediment and on shell-sand are species of the Gromiidae, with rigid pseudopodia, while forms with slender, fragile pseudopodia are entirely absent from sandy bottoms. The pseudopodial structure also has a marked effect on the orientation of the organism in the sediment. Some examples are shown in text-figure 1.

The two types of *Gromia* (text-fig. 1a-b), and the *Hippocrepina* (text-fig. 1c) with its conical test, stand approximately perpendicular to the substratum. *Micrometula* (text-fig. 1d) is in the form of a long, narrow cone, and, like the types previously mentioned, adopts a position perpendicular to the sediment surface. These forms have a single aperture, except for *Micrometula*, in which there is sometimes an accessory aperture at the apex.

The genera *Tinogullmia* (text-fig. 1f), *Phainogullmia* (text-fig. 1g), and *Nemogullmia* (text-fig. 1h), each of which has two functioning apertures, lie horizontally in the sediment. *Nemogullmia* is often looped and folded. *Phainogullmia* and *Nemogullmia* agglutinate particularly large quantities of detritus between their pseudopodia. Because of its size, and because the chitinous tube between the apertures also binds detritus, the part played by *Nemogullmia* in the binding of detritus on loose sedimentary bottoms (at about 100 meters) is particularly important.

The foregoing examples of orientation in the substratum may suggest that foraminiferal types with one permanent aperture take up a vertical position in the substratum, whereas those with two apertures assume a horizontal position. However, the number of the apertures is not the decisive factor. *Hippocrepinella alba*, which has been extensively kept in culture, normally has one functioning aperture, but nevertheless lies horizontally in the sediment. The pseudopodia of this species are so extremely fragile that they cannot obtain an anchorage in the deeper layers of detritus, so that a vertical position is not possible.



TEXT-FIGURE 1

The orientation of some Monothalamia. a-b, allogromiid types; c, *Hippocrepina*; d, *Micrometula*; e, *Bathysiphon*; f, *Tinogullmia*; g, *Phainogullmia*; h, *Nemogullmia*.

Certain species of the genus *Bathysiphon* (text-fig. 1e) that live on a soft bottom are able to stand more or less erect. The aperture at the lower end obtains detritus from the surface of the sediment by means of comparatively rigid pseudopodia, while the aperture projecting above the surface of the sediment takes detritus from the free water. Detritus agglutinates on the plasma tip that projects from the aperture (see text-fig. 1e). These species have very flexible tubes, and the attitude is easily affected by currents.

The latter examples indicate that, just as there are single-apertured species which assume a prostrate position in the sediment, there are also erect types

with two apertures which can obtain detritus through the upper aperture as well as through the lower one.

It will thus be seen that the various monothalamous genera of foraminifera are able to take up detritus from different levels within the few millimeters of bottom sediment that have a high detrital content, depending upon the respective structures of their pseudopodia. This thin detrital layer is greatly reinforced by the agglutination of detritus between the pseudopodia. Furthermore, certain types of benthonic Monothalamia (such as *Bathysiphon*) are able to take in detritus from the free water.

ABSTRACT: This paper discusses the transatlantic correlation of Miocene sediments in southern Trinidad in the light of evidence seen in Malta and Sicily. The Burdigalian/Aquitanian boundary as seen in the Mediterranean region is correlated with the boundary between the *Globorotalia fohsi barisanensis* subzone and the *Globigerinatella insueta* zone of southern Trinidad, British West Indies.

Transatlantic correlation of Miocene sediments

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Prior to 1953, the Cipero formation of southern Trinidad, in its entirety, was ascribed to the Oligocene, and the Lengua/Cipero unconformity was taken to represent a basal Miocene transgression (Stainforth, 1948). Bronnimann (1952) pointed out, however, that the evidence for regarding the upper part of the Cipero formation as Oligocene was weak, and Kugler (1953, 1954) reviewed the evidence of both the macro- and microfaunas of the Cipero and Brasso formations of Trinidad described by various authors, including Rutsch (1934), and tentatively placed the Aquitanian/Oligocene boundary at the base of the *Globorotalia fohsi barisanensis* subzone.

Drooger (1956) used the *Miogypsina*s of the European and Mediterranean regions, with their associated planktonic faunas, to attempt, for the first time, a direct correlation of the mainly planktonic faunas of the Caribbean with the mainly larger-foraminiferal assemblages of certain European and Mediterranean areas. Recently the writer has had the opportunity of studying some well-preserved planktonic faunas from Malta and Sicily, and the results of this study differ from the conclusions drawn by Drooger (1956).

Before discussing these planktonic faunas, it is necessary to review some of the published evidence concerning the stratigraphic ranges of some of the *Miogypsinidae*. Eames (1953) considered the evidence of Senn (1935) and Bronnimann (1940) concerning the ranges of *Miogypsina* in northwestern Morocco, and pointed out that the Upper Oligocene (Chattian) of Senn was in fact Aquitanian. Senn (1935), however, showed that *Miogypsinoides complanata*, *Miogypsina irregularis*, and *Lepidocyclina* (*Nephrolepidina*) *touroueri* occurred together in this

interval. Bronnimann (1940), in his profiles I and V, showed that *Miogypsinoides complanata* and *Miogypsina irregularis* have overlapping ranges in northwestern Morocco. Bronnimann also showed that *Mirolepidocyclina burdigalensis*, *Miogypsina irregularis*, *Miogypsina basraensis*, and *Miogypsinoides complanata* occur in one sample (Profile V, sample 240B). Furthermore, it appears from Bronnimann's paper that the range of *Miogypsina basraensis* is entirely within the range of *Miogypsina irregularis*. Again, Bronnimann (1940, profile V, samples 260 and 277) gives a Burdigalian age for *Miogypsina mediterranea*, which is contrary to the Helvetian age given by Drooger (1956, p. 188).

Very recently, Eames and Clarke (1957) have further reviewed and discussed the occurrence of some *Miogypsina*s. They make the following points:

- 1) *Miogypsinoides complanata* is known to occur in the Aquitanian (basal Miocene) and to be associated with *Miogypsina irregularis* and *Austrotrillina howchini*.
- 2) *Mirolepidocyclina burdigalensis* is considered to be an Aquitanian species and to occur conjointly in the same beds with *Miogypsina irregularis*, *Miogypsinoides complanata*, and *Lepidocyclina* (*Eulepidina*) *dilatata* in typical Aquitanian in the Mediterranean. Eames and Clarke further state that they have not encountered *Mirolepidocyclina burdigalensis* outside the Aquitanian. Finally, Eames and Clarke (1957) state that, in their opinion, Drooger (1956) has drawn the Aquitanian/Oligocene boundary too high and the Burdigalian/Aquitanian boundary too low.

Drooger (1956, p. 188), contrary to the views discussed above, presented a range chart showing various *Miogypsina* species with consecutive ranges which do not overlap; this, in the writer's opinion, is artificial. Drooger (1956, p. 189) stated further that the Burdigalian begins with the life-range of *Miogypsina irregularis*, but the writer has also observed this form occurring conjointly with *Miogypsinoides complanata* in the Lower Coralline Limestone of Malta, as well as in equivalent beds in Sicily. Since *Miogypsinoides complanata* ranges from Oligocene to Aquitanian, and *Miogypsina irregularis* ranges from Aquitanian to Burdigalian (?possibly Vindobonian), it is believed that the Aquitanian may be, in part, defined by the conjoint occurrence of these two species.

In Sicily, *Miogypsina irregularis*, *Miogypsinoides complanata*, *Spiroclypeus blakenhorni* var. *ornata*, *Praerhapydionina delicata*, and *Austrotrillina howchini* occur together, and the writer has recently recognised *Globigerinoides bispherica*, *Globigerinoides glomerosa*, *Globigerinoides transitoria*, and *Globigerinatella insueta* in soft limestones interbedded with hard limestones containing the larger-foraminiferal assemblages listed above. Blow (1956) has shown that the evolution of *Orbulina* from *Globigerinoides bispherica* via *Globigerinoides glomerosa* occurred within a short time-interval in the uppermost part of the range of *Globigerinatella insueta*; consequently, it appears likely that *Orbulina* appeared in the uppermost Aquitanian as defined by the concurrence of *Miogypsina irregularis* and *Miogypsinoides complanata*.

In Malta the Lower Coralline Limestone contains the same *Miogypsina* - *Praerhapydionina* - *Austrotrillina* fauna listed above for Sicily, and this horizon is followed without unconformity by the *Globigerina* Limestone, which contains frequent *Orbulina*. Furthermore, in Sicily the limestones mentioned previously are also followed, without unconformity or diastem, by beds in which *Orbulina suturalis*, *Orbulina universa*, and *Biorbulina bilobata* are common; since these beds also contain *Borelis melo* (Burdigalian to Recent), they are referred to the Burdigalian. The lower part of these Sicilian beds also contains *Globorotalia fohsi barisanensis* as well as *Orbulina*, and the whole planktonic fauna is identical with that of the *Globorotalia fohsi barisanensis* subzone as seen in the Cipero formation of southern Trinidad.

Higher in these Sicilian beds referred to the Burdigalian, transitional forms between *Globorotalia fohsi barisanensis* and *Globorotalia fohsi fohsi* occur, showing the same evolutionary relationships as seen in Trinidad and as described by Bolli (1950). These

transitional forms also occur in the Malta Blue Clay, which overlies the *Globigerina* Limestone of Malta.

At a lower horizon in Sicily than those discussed above, but still within beds referred to the Aquitanian on the basis of their larger-foraminiferal content, *Globigerina ciperoensis* and *Globigerina dissimilis* have been observed, and the planktonic fauna is similar to the fauna of the *Globigerina ciperoensis* zone of the Cipero formation. Thus, summarizing the evidence from Malta and Sicily, it appears that *Orbulina* and *Biorbulina* first occur in the uppermost part of the Aquitanian, whilst *Globigerinoides bispherica*, *Globigerinoides glomerosa*, and *Globigerinatella insueta* also occur in the upper part of this stage. In addition, a fauna identical with the planktonic fauna of the *Globorotalia fohsi barisanensis* subzone of Trinidad follows in strata immediately overlying beds with an Aquitanian larger-foraminiferal assemblage. Hence, the writer correlates the Burdigalian/Aquitanian boundary as seen in Malta and Sicily with the boundary between the *Globorotalia fohsi barisanensis* subzone and the *Globigerinatella insueta* zone in Trinidad.

This correlation is further supported by observations made by Ruscelli (1956), who points out that whereas *Globigerina dissimilis* occurs in the Aquitanian, *Orbulina universa* and *Orbulina suturalis* appear at the base of the Langhian (= Burdigalian) of the Rio Mainia section in Italy. Ruscelli (1956) also points out that *Globorotalia menardii* has its greatest development in the Helvetian of Italy; and although he lists *Globorotalia mayeri* in the Burdigalian, this form is not listed as occurring in the Helvetian. Consequently it appears likely that the Helvetian/Burdigalian boundary may be correlated with the top of the *Globorotalia mayeri* zone in Trinidad.

The Aquitanian/Oligocene boundary cannot as yet be fixed with any certainty in the Caribbean region, although the occurrence of *Globigerina ciperoensis* and *Globigerina dissimilis* in beds referred to the Aquitanian in Sicily is significant, and it appears that at least a part of the *Globigerina ciperoensis* zone of Trinidad must be included in the Lower Miocene.

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MIocene TRANSATLANTIC CORRELATION

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The ages of some Miocene and Oligocene foraminifera

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We are pleased to see, in Drooger's latest paper (1956), that he recognises that much of the so-called "Oligocene" of the Caribbean region is really of Miocene age. This, in our opinion, represents a distinct advance in the regional study and correlation of Tertiary foraminiferal assemblages. At the same time, within the Miocene as now recognised, the evidence presented is not complete, and in some cases published evidence has not been correctly quoted. Consequently, we feel that some brief comment is necessary in order to draw attention to certain important facts.

Miogypsinoides complanata (referred to as a *Miogypsina* in Drooger's text) is said to be a pre-Aquitanean species. This species is also known in undoubted Aquitanian (basal Miocene) in the Mediterranean region and the Middle East, and is known to us to occur in association with both *Miogypsina irregularis* and true *Austrotrillina howchini*. *Mioplepidocyclina burdigalensis* is described as a Burdigalian species, whereas our understanding is that the type level of the species is in the Aquitanian. The species occurs in beds with *Miogypsina irregularis*, *Miogypsinoides complanata*, and *Lepidocyclina* (*Eulepidina*) *dilatata* in typical Aquitanian (basal Miocene) in the Mediterranean region, and we have not encountered it outside the Aquitanian.

Drooger shows the genus *Orbulina* as extending down to the base of the Tortonian. However, typical representatives of the genus are known to us to occur with *Spiroclypeus* and/or *Miogypsinoides complanata* in two areas of the Mediterranean region, in East Africa, and in the Australasian region. All these

occurrences are high in the Aquitanian. The genus is of common occurrence in the Burdigalian.

With regard to the ranges of *Miogypsina* species, as shown by Drooger, it appears that full information has not been extracted from published records. Whereas *Miogypsina basraensis* is shown as uppermost Oligocene only, and *Miogypsina irregularis* as Burdigalian only, reference to Bronnimann's (1940) paper reveals that these two species occur together in sample 95 of Profile I and in samples 240B and 241 of Profile V, all three occurrences appearing to us to be of Aquitanian age.

It is therefore evident to us that Drooger's table requires amendment. The base of his Aquitanian has been taken a little too high, and the base of his Burdigalian too low. The ranges of *Miogypsina* species require some adjustment, and *Orbulina* (including *Orbulina suturalis* and *Orbulina universa*) should range down into the uppermost Aquitanian.

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Comments on European Tertiary pollen studies

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[EDITORS' NOTE: This note is a condensation of the fourth of ten papers presented at a round-table program on plant-microfossil systematic methods to which the Paleobotanical Section of the Botanical Society of America devoted one day of its annual meeting at East Lansing, Michigan, in September, 1955. Other papers presented at this round-table program will be published in future numbers of this quarterly.]

The classification of pollen is an interesting and yet vexing problem. The palynologist making analyses of postglacial peats readily identifies the fossil pollen and applies the botanical name of the plant which produced it. Likewise, pollen from the sediments of various Pleistocene interglacial ages are correlated with modern genera, although some of the species may no longer grow in the area. A survey of many publications shows that, as the sediments under investigation are progressively older, from Pleistocene to Pliocene, to Miocene, to Eocene, and into the Cretaceous, less and less of the pollen is correlated with modern botanical genera. Part of the difficulty arises from the lack of knowledge of modern pollen, and part from a prevailing geological concept that fossils in different geological horizons must be different from the modern forms, or we are denying evolutionary development.

There are many publications intended for use in identifying modern pollen, most of which cover only "local floras." The limited scope of these publications has been a material handicap to workers interested in Tertiary palynology. So many workers have found such an array of unknown forms in Tertiary deposits that there has been a tendency to consider these pollens as representing extinct species. Part of this may be so, but the changes in the climates of the world have caused many phytogeographic shifts in the vegetation. What was a common assemblage or community in Tertiary times may now be so scattered that the various components occur on several continents.

Dr. J. B. Simpson of Edinburgh has in preparation a study of the flora of Scottish Tertiary coals. The plates he has prepared show the fossil grain and its modern counterpart. He has identified pollen of plants which today occur in southern Europe, Africa, Asia, Australia, and North and South America. This is a very strange assemblage, but not as impossible as it seems at first. The writer has collected, at Düren, Germany, fossil cones indistinguishable from *Sequoia sempervirens* of western North America and *Glyptostrobus pensiles* of eastern Asia, as well as a variety of seeds and fruits of plants that are now growing either in Asia or North America. Thus it is easy to see some of the difficulties which exist when one tries to pin down fossil pollen to botanical genera. It is necessary to have an almost world-wide collection of modern species to make botanical identifications of Tertiary pollen. The excellent publication of Professor Gunnar Erdtman, "Pollen morphology and plant taxonomy," is helpful because of its world-wide scope.

A classification of modern pollen into artificial groups was presented by Iversen and Troels-Smith (1950) and was repeated again in the "Textbook of pollen analysis" by Faegri and Iversen (1950). This classification has formed the framework of several artificial systems.

A series of publications by Robert Potonié and his coworkers, which have appeared over a period of about 25 years, has greatly influenced Tertiary palynology. These show many developmental changes in concepts as well as in nomenclature. Potonié (1931) placed fossil spores and pollen in the form-genera *Sporites* and *Pollenites*. In a later publication (1934), he classified fossil pollen within the framework of a botanical classification by placing the species of *Pollenites* in their respective or suggested families. Potonié initiated the system of adding "-pollenites" as a hyphenated suffix to the generic name, as in *Alni-pollenites verus*. If he could not give a positive generic identification, he indicated the

uncertainty with a question-mark, as in *Coryli?-pollenites coryphaeus*. When he was uncertain of its natural affinity, he used such combinations as *Pollenites* cf. *levis* R. Pot. Raatz (1937) changed *Alni-pollenites* and *Ilic-pollenites* to *Alnus-pollenites* and *Ilex-pollenites*, respectively. Later, Potonié, Thompson and Thiergart (1950) proposed adding the suffixes "-oidites" to generic names and "-oides" to specific names, thus making such generic combinations as *Quercoidites* and *Salicoidites*, and specific combinations like *Fagus silvaticoides*. These workers were attempting to correlate fossil pollen with existing genera and species, and, at the same time, to indicate their fossil nature. This procedure has been designated as the "half-natural" system. Potonié (1951, 1952) changed names such as *Quercoidites* to *Quercopollenites*, and apparently considered these categories as organ-genera. Thus, he changed his system of classification from a form-genus, *Pollenites*, with no botanical affinities, to one with suggested botanical relationships; then he changed to a "half-natural" system of classification by the use of existing botanical names, and finally he adopted a system of organ-genera. This cycle of treatment is bound to be interpreted in different ways and thus cause much confusion.

Thiergart (1940) correlated his fossil pollen with existing generic names insofar as he was able to do so, and used the form-genera *Sporites* and *Pollenites* for the unknowns. Several workers have believed that Tertiary pollen cannot be correlated with existing genera. It is interesting to note that Thiergart reported *Picea* and *Pinus* pollen from the late Pliocene to as far back as the Eocene. He also identified Eocene fossil pollen as belonging to the genera *Rhus*, *Ilex*, *Engelhardtia*, *Diospyros*, *Castanea*, and *Castanopsis*.

Thompson and Pflug (1953) recognized that the numerous proposals of Potonié, including uncertain genera indicated by "?" and other unsound taxonomic procedures, had created much confusion. They therefore established a system of classification based upon the morphology of pollen—a system of organ-genera. Each genus had its morphological description and, for the first time, a "genotype" for validating the generic description. Unfortunately, they did not save the type specimens. They expected the photographic illustrations cited with each specific description to serve as a holotype. It should be mentioned that part of this morphological system is based upon the system of classifying modern pollen into sections proposed by Iversen and Troels-Smith (1950), even to the incorporation of the stem of the section name with the word "pollenites,"

without hyphenation, thus creating such names as *Tricolpopollenites* and *Stephanoporopollenites*. Pflug (1953) reinserted the hyphen in many of these genera, for example, *Stephanoporo-pollenites*.

Ingwersen (1954) classified many of his Danish lignite pollens in botanical genera. He felt that his knowledge of pollen was not sufficient to permit him to correlate positively all of the fossil pollens with the present-day species, but he did suggest that certain modern species are very similar, differing only in minute details.

Several palynologists have deplored the haphazard application of artificial names, "half-natural" names, and botanical names to fossil pollen. It has been pointed out that many of the Tertiary plants are extinct, and that there is no possibility of placing them in existing genera. Many workers insist that fossil pollens should have only one name.

It will be difficult because of the diversity of opinion, but nevertheless it will be possible to harmonize these differences by the creation of a dual system of classification and nomenclature on the same basis that mycologists use for fungi. They use form-genera and species based upon the obvious morphology of the imperfect stages. When the perfect stage is found, the organism is integrated within the natural system. Although the name of the perfect stage is the one usually applied to the fungus, the rules sanction the use of form-genera names when one is working with the imperfect stage.

We need a system of classifying pollen and spores based upon their morphology—one which will be usable for the rapid determination of the individual entities of a complex assemblage in a given sample. Such a system would be of great value to the palynologist in correlating geologic strata.

We also need to know the botanical identity of entities in so far as botanical classification is possible, in order to gain insight into paleoecological relationships, past climatic conditions, evolution and migration of floras, and the bearing that fossil floras have upon our present-day plant geography. It has been demonstrated that there is a relationship between entities and assemblages and their abundance, on the one hand, and the location of oil-bearing strata on the other. It seems reasonable to expect that a knowledge of botanical affinities and ecology could contribute to our understanding of oil formation.

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Further occurrences of Botryococcus in western Pakistan

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In a recent article, Traverse (1955) referred to the occurrence of *Botryococcus* in lignites and other Tertiary sediments. To his list of occurrences in the India-Pakistan area may be added two other localities: Makrach, in the Punjab Salt Range, and Kohat, just across the Indus River, west of the Salt Range. Both localities are in western Pakistan, and the occurrences were reported by Lahiri (1945), who also gave the "oil yield" of these and other samples examined by him. Down and Himus (1940) also refer to oil shales and kerogen shales from Kohat as containing spores and algae.

The Makrach sample is from bituminous shales associated with dolomite and gypsum occurring at the top of the Punjab Saline Series. The age is Cambrian or pre-Cambrian; the Punjab Saline Series is overlain by Cambrian rocks (see Gee, 1945, table 1).

The Kohat sample is from an oil shale associated with gypsum capping the salt deposits near Kark. The age in this case is Eocene.

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Note on *Sansabella stewartae* Marple

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When the original description of *Sansabella stewartae* Marple was published (Marple, 1952, p. 936), no individual specimen was selected as the holotype because of the variation in the forms believed to belong to this species. The description was based on ten specimens considered to be cotypes, all of which are deposited in the Geological Museum of the Ohio State University (OSU) and all of which were figured (Marple, 1952, pl. 135, figs. 9-18).

Sansabella stewartae has four sorts of adult individuals: Those in which the left valve is the larger are designated as sinistral; those in which the right valve is the larger are designated as dextral; and in both the sinistral and the dextral group there is what appears to be sexual dimorphism. The marginal spines become progressively longer in younger and younger instars of all types.

It now seems desirable to select a lectotype for this species, and a sinistral female, OSU 20475 (Marple, 1952, pl. 135, fig. 11), from the lower Mercer limestone exposed in the Baltimore and Ohio Railroad cut at Somerset, Perry County, Ohio, is so designated. This specimen was selected because sinistral females are the most abundant group in our collections.

The other cotypes (now paratypes) figured on plate 135 (Marple, 1952) are identified as follows: Fig. 9, sinistral male, OSU 20473; fig. 10, dextral male, OSU 20474; fig. 12, dextral female, OSU 20476; fig. 13, dextral male, OSU 20477; fig. 14, sinistral female, OSU 20478; fig. 15, dextral female, OSU 20479; fig. 16, young instar, OSU 20480; and fig. 17, young instar, OSU 20481. All of these specimens are from the lower Mercer limestone exposed in the Baltimore and Ohio Railroad cut at Somerset, Ohio. Fig. 18, interior of the left valve of a sinistral male, OSU 20482, is from the lower Mercer limestone exposed in the ditch at the angle in the road in the NW $\frac{1}{4}$ sec. 18, Hopewell Township, Muskingum County, Ohio.

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Construction of pinhole diaphragms for use in photomicrography

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The author has received many requests for the description of a method for making the pinhole diaphragms referred to in his article "New methods and techniques in the photography of microfossils" (*Micropaleontology*, vol. 2, no. 1, pp. 37-56, 1956). During a visit to the United States in 1954, the problem of making pinhole diaphragms of absolute accuracy was presented to two leading microscope manufacturers. Although both were impressed with the results, neither wanted to go into the research necessary for making such devices without previous knowledge of the possibilities for selling them. At that time, no important publication describing methods of photography with pinhole diaphragms had been issued, and these methods were known only to a very limited number of workers. It is hoped that, because of the interest developed as a result of the publication of an article on pinhole diaphragms, microscope manufacturers will turn their attention to the problem and will put on the market pinhole diaphragms adaptable to the standard objectives. In the meantime, however, each worker must construct his own.

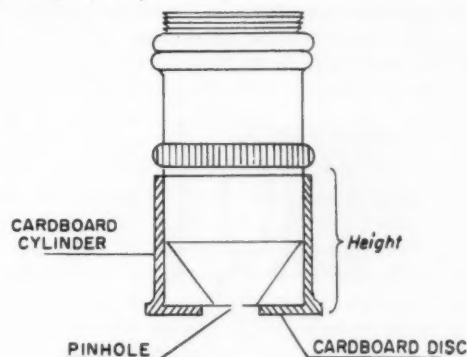
The best material that the author has found available for making pinhole diaphragms is brass shim stock, which can be obtained in any hardware store. For pinhole diaphragms from 100 to 250 microns in diameter, shim stock 0.001 inch thick is used. For diaphragms of 300 microns and larger, shim stock 0.002 inch thick is excellent material.

The step-by-step procedure for making a 650-micron pinhole diaphragm for use with the 10 \times , 16 mm.

objective is described and the necessary materials listed below:

STEP 1

Make a cardboard cylinder that fits snugly over the objective upon which the diaphragm is to be mounted (text-fig. 1).

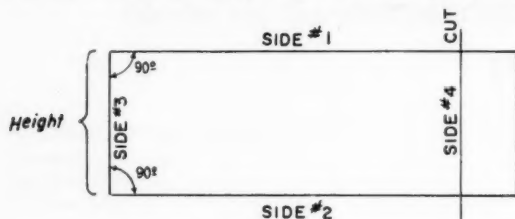


TEXT-FIGURE 1

Materials needed: 1) A piece of cardboard, which must be thin, stiff and flexible; it should not crack when bent. 2) Cotton string. 3) One can of quick-drying "Ambroid Liquid Cement." 4) A trimming board and scissors.

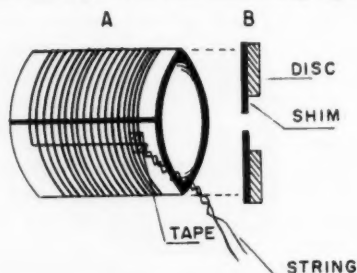
Procedure: Cut a strip of cardboard with the height equal to that portion of the objective's barrel which extends from the plane of the lens to the end of the first segment of the barrel. In the older types of

objectives, this segment ends in a ring of high relief, which acts as a stop. The objectives of modern biological microscopes usually have plain barrels without high-relief rings around them. For an objective of the latter type, a cardboard cylinder half the height of the barrel is appropriate. The cardboard strip should be long enough to wrap around the cylinder about one and one-quarter times. Sides 1 and 2 of the cardboard strip (see text-fig. 2) must



TEXT-FIGURE 2

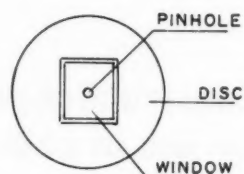
be absolutely parallel and straight, and side 3 must be straight and at right angles to sides 1 and 2. Wrap the strip of cardboard around the barrel of the objective, leading with side 3 and making one complete turn. Mark the meeting point on one edge of the strip. Unwrap the strip, draw a line indicating side 4, perfectly square to sides 1 and 2, at the point marked on the edge, and cut side 4 with the trimmer. Wrap the cardboard snugly around the objective again, in order to make sure that sides 3 and 4 fit exactly against each other. Take the free end of the string and attach it to the outer edge of the strip as shown in text-figure 3. Pull the string tight toward



TEXT-FIGURE 3

the opposite edge, and then begin winding the string closely around the cylinder, working toward the nose of the objective and covering the portion of string that runs lengthwise. Stop the winding about $\frac{1}{8}$ inch before it reaches the edge of the cardboard and at the point where the free end of the string protrudes. Make a knot with the two ends, and then cut the string (text-fig. 3A). Now make sure that the tightly wound cylinder slides with ease along the

barrel of the objective, and, without separating the two, apply a heavy coat of liquid cement over the cardboard cylinder. Let it dry, then apply a second coat of cement.



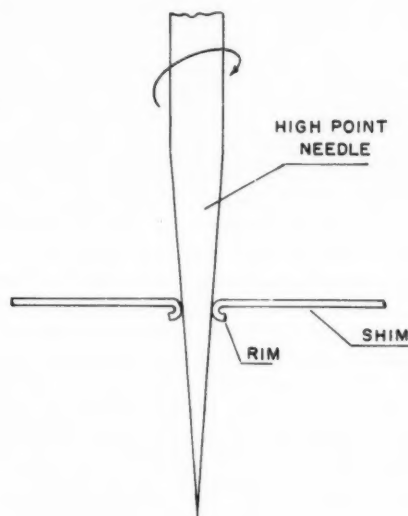
TEXT-FIGURE 4

STEP 2

Make a 650-micron hole in a piece of shim stock.

Materials needed: 1) A piece of brass shim stock 0.002 inch thick. 2) A dissecting needle with a very long, tapering point. 3) Scissors. 4) Dividers. 5) Honing stone. 6) A small piece of soft wood.

Procedure: Prepare the needle first by sharpening it to a long, tapering point, inspecting it under the microscope (text-fig. 5). This is the tool which will



TEXT-FIGURE 5

be used to make the pinhole. Using the dividers, lightly inscribe a circle $\frac{1}{8}$ inch greater in diameter than the cardboard cylinder on the piece of shim stock (text-fig. 3B). Do not perforate the shim at the center of the circle, merely mark it for punching.

CONSTRUCTION OF PINHOLE DIAPHRAGMS

Now place the piece of shim upon the piece of soft wood, and with the dissecting needle puncture the smallest hole possible, at the point marked in the center of the circle, using a light rotary motion. The edges of the hole on the under side of the shim will curl outward, forming an undesirable raised rim (text-fig. 5). Grind this rim off with the honing stone, then measure the diameter of the hole, using transmitted light in a microscope equipped with a micrometer. If the needle has been sharpened to the proper point, and if it barely went through the shim, the hole will be approximately 100 microns in diameter. It is important to perform this operation correctly in order to acquire the feel of how much to punch. Place the shim again on the soft wood, and enlarge the hole somewhat more; again grind away the rim, and measure the diameter of the hole. Repeat this operation as many times as necessary until the hole is 650 microns in diameter. Two important points in punching the pinhole are: (1) use a very light rotary motion of the needle in order to produce a round hole, and (2) grind the rim *before* measuring the hole, as the hole always becomes larger after grinding.

Draw and cut a cardboard disc of the same diameter as the circle inscribed on the shim. Cut a window $\frac{3}{8}$ inch square at the exact center of the cardboard disc. Apply a very thin coat of cement to one side of the disc and fit the disc into the circle inscribed on the punctured piece of shim. Press the two pieces tightly together until they adhere to each other well. Wait until the cement dries and hardens, then trim the shim along the inscribed circle (text-figs. 3B and 4). The pinhole diaphragm is now ready to be attached to the cylinder.

STEP 3

Fit and glue the diaphragm to the cardboard cylinder.

Necessary equipment: A viewing box.

Procedure: Slide the objective into the cylinder, and place both, lens side down, on the glass surface of the viewing box. Adjust the cylinder until its edge touches the glass. The edge of the cylinder and the

surface of the lens are now in the same plane. In order to avoid scratching the lens, make sure that the glass surface of the viewing box is free from dust.

Place the diaphragm, with the *metal face up*, on the glass surface of the viewing box, and carefully pour a thin ring of cement around its edge. Quickly place the objective, with the cylinder, over the diaphragm. Look through the objective from the threaded end into the illuminated box and locate the illuminated circle produce by the pinhole. Adjust this circle so that it lies in the exact center of the field of the objective, and hold it in this position until the cement hardens. Then lift the objective and add more cement along the line of contact between the cylinder and the diaphragm, in order to reinforce the union between them. Remember that both the piece of shim and the cardboard disc were cut $\frac{1}{8}$ inch larger in diameter than the cylinder. This was done in order to have a margin upon which to move the cylinder over the diaphragm during the gluing operation, so that the hole could be brought into the exact center of the field of the objective, or in other words, so that the optical axis of the objective would lie exactly in line with the center of the pinhole. Consequently, there is now a flange around the diaphragm. This flange can be trimmed off with scissors once the cement has hardened completely.

Two essential requirements must be fulfilled before a pinhole diaphragm will be serviceable: It must be placed in the exact center of the outer lens of the objective, in line with its optical axis, and it must be in close contact with the lens. The construction of pinhole diaphragms less than 250 microns in diameter is somewhat different from the procedure outlined above. The shim stock used is brass, 0.001 inch thick. Such diaphragms are employed with objectives of very short focal length ($25\times$, $45\times$), and if the cardboard reinforcing disc is placed as indicated above, it will occupy all of the space available for illumination. In these diaphragms, therefore, the shim must lie on the outside and the reinforcing disc on the inside. The window in the reinforcing disc must then be made large enough to permit close contact between the lens and the perforated shim.

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news reports

CANADA—WEST COAST

University of British Columbia

C. James Gilders recently completed his thesis, entitled "A palynological study of the Point Grey sediments." He has found the first conifer pollen to be reported from the late Wisconsin interglacial peats underlying Point Grey, Vancouver.

Ray Cox is beginning a study of foraminifera collected by Professor W. H. Mathews during the summer of 1956 from the bottom of Dixon Entrance, north of the Queen Charlotte Islands. Douglas Lockie has begun a petrographic study of Mesozoic and Paleozoic organic limestones from Vancouver Island and the Strait of Georgia area. His initial work will be on specimens from the Sutton collection at the University of British Columbia.

W. R. Danner is continuing his study of the organic limestones of western Washington, and has discovered some new Permian fusulinid and algal localities. Endothyroid foraminifera have been found for the first time in western Washington. Algae have been identified in an Oligocene limestone on Bear River, Pacific County, Washington. He is also making a thin-section collection of local Paleozoic and Mesozoic radiolarian ribbon cherts.

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EGYPT



RUSHDI SAID

The establishment of a micropaleontological laboratory by the National Research Council at Cairo marked a step forward in the advancement of our science. All cores and cuttings from wells drilled in Egypt by oil companies since the beginning of the century that had been in the possession of the Government Fuels Department will now be properly stored at this laboratory and systematically studied by a competent staff. Dr. S. E. Ansary is in charge of setting up the project. Dr. Ansary has recently completed a study with Dr. M. M. Ismail on some Eocene foraminifera from the Helwan area south of Cairo, and has discussed the significance of these fossils for determining the Middle Eocene—Upper Eocene boundary.

Y. Bishay has just come back after a year's study with Professor W. Leupold on some larger Eocene foraminifera from Egypt, at the Swiss

Federal Institute of Technology at Zürich. Mr. Ghorab is continuing his work on the systematic study of the Upper Cretaceous foraminifera of Egypt. In this connection Ghorab read a paper before the Geological Society of Egypt, on the introduction of stratigraphic rock terms in Egypt. Mr. Ghorab has also completed a study with Dr. Ismail on the microfacies of some Eocene rocks of the Helwan area.

Work by Said and Basiouni on the ostracodes of the so-called Pliocene of the Nile Valley has given further evidence that the age of the rocks previously considered to be Pliocene is actually Lower Pleistocene. Said and Basiouni have also completed a short paper on the distribution of Miocene faunas in the Gulf of Suez region and on the influence of structures on their distribution. These two authors have also completed a note on the systematic study of some calcareous algae from Upper Miocene rocks in the Gulf of Suez area. Said and Kenawy's paper on the Turonian foraminifera of Abu Roash is now in press, and is due to appear in the Contributions from the Cushman Foundation for Foraminiferal Research.

Colleagues who passed through Cairo during the past year were Professors J. J. Graham, M. F. Glaessner, and H. A. Ireland, and Dr. A. ten Dam.

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MIDDLE EAST



MAX CHATTON

IRAN

Your correspondent is pleased to be able to include a new section in his report this year. Contact has been made with paleontologists and geologists working in Iran for the Iran Oil Company. We welcome them among us, and to mark our appreciation we give them the place of honour.

Dr. A. Gansser is now leading the team of Swiss geologists working for the Iran Oil Company. Their activity covers the entire Persian territory outside the concession formerly held by the Anglo-Iranian Oil Company, now the Consortium. Geological surveys started in 1950. Up to April, 1955, Dr. M. A. Furrer was responsible for the paleontological work of the survey. He then left Iran to undergo further training and specialization in the United States. Dr. F. Allemann took over his place; he is assisted by Dr. P. A. Soder when the pressure of work requires additional help. A. Gollestanah, an Iranian geologist, was trained in paleontology by the Swiss team during 1953 and 1954. He is now working at Masdjid-i-Soleiman for the National Iranian Oil Company. Some of their work has appeared in two papers: "New aspects of geology in central Iran," by A. Gansser, and "The Oligo-Miocene marine formation in the Qum region (central Iran)," by M. A. Furrer and P. A. Soder. Both of these papers were published in Section 1 (A) 5 of the Proceedings of the Fourth World Petroleum Congress, Rome, 1955. The most spectacular result of this

survey, however, is the recent discovery of a major oil field at Qum, about which a great deal has already been said.

IRAQ

In Kirkuk, H. V. Dunnington, Divisional Paleontologist, had quite a busy summer. With Dr. R. C. van Bellen on home leave, he had to cope alone with all stratigraphic problems, to say nothing of his administrative work, as he was also acting as Senior Geologist. It is no wonder, then, that we did not hear much from him.

Dr. van Bellen has published his long-awaited paper "The stratigraphy of the 'Main Limestone' of the Kirkuk, Bai Hassan and Qarah Chauq Daghs structures in north Iraq" (1956, *Inst. Petr., Jour.*, vol. 42, no. 393). This up-to-date account of the intricate problems of overlapping reefs, back-reefs, fore-reefs, and off-shore sediments, already dealt with briefly in previous publications (especially by Dr. F. R. S. Henson), will surely become a classic in this field, and will undoubtedly be of interest and help to geologists engaged in similar problems.

The Basrah Petroleum Company will embark next year on an extensive wildcatting program. W. Sugden, now Divisional Geologist at Qatar, will shortly be transferred to Basrah to deal with the paleontological and stratigraphic aspects of this program. We wish him good luck.

PERSIAN GULF

Dr. M. Chatton, Divisional Paleontologist, is still fully engaged in unraveling the stratigraphy of newly explored parts of Oman. Hitherto unknown and politically inaccessible regions of this vast country have been surveyed by a team of geologists of the Petroleum Development (Oman) Company, led by D. M. Morton, Divisional Geologist. The results are most interesting, and it is hoped that they can be made known in the near future.

Dr. Chatton has planned for some time to publish a paper on some new

Middle Eocene microfaunas discovered in Trucial Coast, but priority work has prevented him from doing so. However, now that A. J. Standring, who has just finished his studies at Bristol University, is assisting him, he hopes to be able to complete this paper.

The second off-shore well drilled by the Shell Oil Company at Idd el Sharqi, near Halul Island, has kept Dr. W. Bisig, stationed at Doha (Qatar), busy with paleontological determinations and stratigraphic correlations.

MAX CHATTON

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POLAND



FRANCISZEK BIEDA

During the past two years (1955 and 1956), a number of papers on fossil micro-organisms appeared in Polish periodicals. Most of them concern foraminifera. They will be reviewed in order of their geologic ages.

S. Duszyńska has published the first paper ever written on the foraminifera of the Polish Devonian (1956, *Acta Paleontologica Polonica*, Warsaw, vol. 1, no. 1). She describes three species of arenaceous foraminifera belonging to the genera *Moravamina*, *Semitextularia* and *Textularia*(?), indicating that these species show great variability of characters. It should be pointed out here that this paper appeared in the first volume of a new Polish periodical devoted to paleontology, which contains many works on micropaleontology.

A paper by W. Bielecka on the foraminifera of the Zechstein and the Triassic of the northwestern periphery of the Święty Krzyż (Holy Cross) Mountains (1956, Inst. Geol., Bull., Warsaw, no. 102) is also the first of its kind in Polish micropaleontology. The author found that the foraminiferal fauna of the Lower and Middle Triassic is scarce and badly preserved; it contains a few genera of arenaceous foraminifera. In the Lower Triassic (Bunter), there are ostracodes, Characeae and megaspores. The author did not identify these micro-organisms in detail, nor was she able to determine the age of the strata by means of the foraminifera.

Some other papers have contributed to the knowledge of Polish Jurassic foraminifera. J. Kopik gives a list of foraminifera from the Aalenian in the "Borucice" deep boring near Łęczyca, district of Łódź (1956, Inst. Geol., Bull., no. 102). The list includes forty-five species, twenty-nine of which are arenaceous. He also found a few ostracodes and megaspores. In the Bajocian of the same boring, small numbers of ostracodes and foraminifera were found.

In another paper, Bielecka describes the microfauna of the lower Malm in the vicinity of Trzebinia, Upper Silesia (1956, Inst. Geol., Bull., no. 102). She has established the presence of foraminifera in a series comprising the Divesian, Nevisian, and Argovian, with a thickness of over 50 meters. Ninety per cent of the foraminifera are calcareous. The author differentiates seven zones based on foraminiferal assemblages. Of these, zone I is Divesian, zones II-V Nevisian, and zones VI-VII Argovian. She gives a list of sixty-five species of foraminifera, and mentions the presence of some Radiolaria and ostracodes, which are not identified.

Several papers are devoted to the foraminifera of the Polish Cretaceous. In his work on the foraminifera of the lower Senonian in the vicinity of Kraków (1956, Polsk. Tow. Geol., Roczn., Kraków, vol. 23 (1955)),

S. Liszka gives a list of eighty-seven species, of which fifty-seven are calcareous and thirty arenaceous. This microfauna was found in grayish-yellow marl with an admixture of glauconite, in the zones of *Actinocamax granulatus* and *Actinocamax quadratus*. Forty-seven species are described.

K. Pożaryska and A. Urbanek have published the results of their research on the evolution of the species *Lagena sulcatiformis* Pożaryska and Urbanek, from the Polish Upper Cretaceous (1956, Acta Pal. Polonica, vol. 1, no. 2). The material was collected from four zones: The middle and upper Maestrichtian, and the lower and upper Danian. The authors observed the following changes in the shell form: In the lower strata the shell is globular, while in the upper strata the shape becomes elongate. This species lived continuously in the same basin, thus it is an example of the evolution of an autochthonous population.

Species of *Globotruncana* from the Polish Upper Cretaceous are the subject of three papers: W. Pożaryski and E. Witwicka (1956, Inst. Geol., Bull., no. 102) established the presence of *Globotruncana* in a series extending from the Cenomanian to the upper Maestrichtian. The material was collected in the middle Vistula valley west of Lublin. The majority of the species of *Globotruncana* were found in the lower Turonian (eleven species and varieties); nine were found in the upper Campanian. Altogether, eighteen species and varieties were determined. The authors compare the first appearances of assemblages of *Globotruncana* in this area with those of neighboring regions.

S. Alexandrowicz describes eight species and subspecies of *Globotruncana* from the conglomerates and limestones of the Turonian in the vicinity of Kraków (1956, Acta Geologica Polonica, Warsaw, vol. 6, no. 1). The specimens were identified solely from sections.

A rich *Globotruncana* fauna was found by M. Książkiewicz in the Carpathian flysch near Wadowice (1956,

Polsk. Tow. Geol., Roczn., vol. 24, no. 2-3). In the village of Bachowice, numerous exotic blocks of Paleozoic, Jurassic and Cretaceous crystalline rocks are found, containing both macro- and microfaunas; of the latter, species of *Globotruncana* are the most numerous. The author describes twenty species and subspecies which he was able to identify on the basis of both sections and specimens isolated from the rock. These species indicate that the ages of chalks with *Globotruncana* range from Cenomanian to Maestrichtian. The author also mentions the occurrence of two species of the genus *Calpionella* in the Tithonian.

Foraminifera of the Cretaceous and Tertiary Carpathian flysch are treated in three papers. Problems of the stratigraphy of the so-called "Pieniny Klippen-Belt mantle," and especially of the "Puchow Marls," are the subject of a paper by K. Birkenmajer (1954, Inst. Geol., Bull., no. 88). The author gives lists of foraminifera from several stratigraphic zones. His collaborators in determining them were S. Geroch, who identified the smaller arenaceous foraminifera, and F. Bieda, who identified the larger ones. On the basis of their joint findings, Birkenmajer concluded that the age of the "Klippen-Belt mantle" in the Pieniny Mountains ranges from upper Santonian to Lower Eocene, and even possibly to Middle Eocene. The "Puchow Marls," formerly considered to be of Maestrichtian age, probably belong to the Danian or Lower Eocene.

Another stratigraphic work is a paper by S. Geroch and R. Gradziński on the sub-Silesian series in the tectonic window of Żywiec (1955, Polsk. Tow. Geol., Roczn., vol. 24, no. 1). Strong tectonic disturbances are discernible in this flysch series. The authors collected faunas of arenaceous and calcareous foraminifera from many zones. The ages of these zones are determined as Campanian to Upper Eocene. The paper includes lists of foraminifera, the larger forms identified by F. Bieda. Some species of smaller foraminifera are described.

S. Geroch describes a new genus, *Saccamminoides*, of the family Saccamminidae, from the Eocene (1955, *Polsk. Tow. Geol., Roczn.*, vol. 23). This genus is characteristic of the lower stages of the Eocene of the Carpathian flysch.

A more extensive work is one by E. Łuczowska on the Tortonian foraminifera of the Chodenice and Grabowiec beds in the vicinity of Bochnia (1955, *Polsk. Tow. Geol., Roczn.*, vol. 23). The author collected microfaunas from the two rock complexes, which are considered to be of different ages; the Chodenice beds are assigned to the lower Tortonian, and the Grabowiec beds are attributed to the middle Tortonian. The microfaunas of these complexes are similar in composition, the difference being that the Chodenice beds contain Radiolaria and sponge spicules, which are absent from the Grabowiec beds. In both complexes, Pteropoda of the genus *Spiralis* and other microorganisms, such as ostracodes, occur. The author is concerned, however, only with foraminifera, of which 116 species were identified. Eleven of them are arenaceous forms, and were found only in the Grabowiec beds. Fifty-two species and varieties are described, nine of which are new. A. Sulimski describes thirteen species of the Miliolidae from the Tortonian and Sarmatian of Suchowola on the southern slope of the Holy Cross Mountains (1956, *Acta Pal. Polonica*, vol. 1, no. 1).

Papers on microfossils other than foraminifera have also been published. In the paper by M. Książkiewicz mentioned above, the occurrence of the genus *Calpionella* in exotic blocks of Tithonian age at Bachowice is noted. In a paper by K. Birkenmajer and J. Znosko (1955, *Polsk. Tow. Geol., Roczn.*, vol. 23), the former author reports three species of the genus *Calpionella* in the upper nodular limestone of the Pieniny Klippen-Belt, of Tithonian age. A problematic microorganism, *Globochaete alpina*, is also mentioned in this paper. It occurs in the same limestone but in older beds, of Kimmeridgian age.

R. Kozłowski (1956, *Acta Pal. Polonica*, vol. 1, no. 3) describes the buccal apparatus of Polychaeta (Annelida) found in Ordovician glacial erratics collected from the Pleistocene of northern Poland. This is the first paper on these fossils published in Poland; the discovery of whole buccal apparatuses is important. The author describes two new genera, which include three species.

In a joint paper by W. Krach and W. Nowak (1956, *Polsk. Tow. Geol., Roczn.*, vol. 25, no. 1), the former author indicates the occurrence of three species of Pteropoda of the genera *Balantium* and *Vaginella* in the Miocene of the Andrychów, between Wadowice and Bielsko. The age of the beds is believed to be Helvetian(?) to lower Tortonian.

Papers on Ostracoda have also been published for the first time in Polish journals. F. Adamczak (1954, *Acta Pal. Polonica*, vol. 1, no. 1) describes two species of the genus *Polyzygia* from the Givetian of the Holy Cross Mountains. The author indicates that there is great variability in these forms, and describes the ontogenetic stages of the carapace.

J. Choczewski (1956, *Polsk. Tow. Geol., Roczn.*, vol. 25, no. 1) describes Ostracoda from the Sarmatian of Dwikozy near Sandomierz in central Poland. The fauna consists of twenty-nine species of the suborder Podocopa, of which twenty-seven belong to the family Cypriidae.

Palynology is represented by two monographs by M. Rogalska on spores and pollen grains from the Liassic of Poland. These are the first papers to appear in Poland on the palynology of Mesozoic deposits. In her earlier work (1954, *Inst. Geol., Bull.*, no. 89), the author describes spores and pollen grains from the brown coal of Blanowice, near Zawiercie. She reports the occurrence, in equal numbers, of Pteridophyta (Filicinae) and of Gymnospermae (Coniferae). She estimates the age of the coal beds as Lias α .

In a later paper (1956, *Inst. Geol., Bull.*, no. 104), Rogalska presents a spore and pollen analysis of the Mroczków-Rozwady area in the Opoczno district. She describes and illustrates (in thirty-two plates) spores and pollen grains from four geologic series, the Ostrowiec, the Zarzecze, the Gromadzice, and the Zagaje series. The spores found represent mosses, ferns, lycopodia and equiset, and the pollen grains represent Pteridospermae, Cordaitinae(?), Cycadinae, Bennettitinae, Ginkgoinae, and Coniferae. The microfloral association contains predominantly forms of the Lias α .

Two short notes on *Pterocarya* pollen in the Pleistocene of Poland were also published. A. Srodoń (1955, *Acta Soc. Bot. Poloniae*, vol. 24) found *Pterocarya* sp., probably *Pterocarya fraxinifolia* Spach, in the Mindel-Riss interglacial deposits of Góścięcin (Kostenthal), near Koźle, in the Sudeten Mountains foreland. A. Stachurska (ibid.) found pollen grains of *Pterocarya stenopis* DC in the same interglacial deposits at Włodawa, in eastern Poland.

FRANCISZEK BIEDA
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SWITZERLAND



MANFRED REICHEL

The Institute of Geology and Paleontology at Basel had the pleasure of visits during the past two years by a number of foreign micropaleontologists who wanted to see our es-

tablishment and our teaching collections. Professor M. F. Glaessner of Adelaide stayed some days at Basel, and gave an interesting lecture on Australia. Z. Reiss of Jerusalem looked over our material during a three-week stay, and M. J. Mijer of Liège, P. Rat of Dijon, and Mr. Glintzboeckel of Tunis made shorter visits. Other visitors to the laboratory included C. W. Drooger of Utrecht, J. J. Bizon of Montpellier, Miss Germaine Aurouze of Paris, and H. S. Edgell of Australia. During the past winter term, Miss C. Panseri of Rome and Miss L. Spada of Naples completed their studies in micropaleontology at our laboratory.

As in our previous reports, we shall mention here studies which have been published recently in Switzerland on micropaleontological subjects, as well as geologic papers in which many microfossils are cited.

A. Bally of Zürich, in his extensive thesis on the geology of the Abruzzi Mountains of Italy (Zürich, 1954) gives a large number of lists of foraminifera. Most of the faunas are from the Upper Cretaceous, Eocene, Oligocene and Miocene. H. Bartenstein and F. Burri have published a paper on the Upper Jurassic to Cretaceous transition beds in the Swiss Jura (1955, *Eclogae Geol. Helv.*, vol. 47, no. 2). They give tables showing the distribution of ostracodes and foraminifera, and indicate that there is good correlation with the faunas of northern Germany.

P. Bronnimann and N. K. Brown of Cuba have published an important work on the taxonomy of the Globotruncanidae (1956, *Eclogae Geol. Helv.*, vol. 48, no. 2). The paper is copiously illustrated. It is an interesting attempt to unite with the Globotruncanas pelagic foraminifera from the Upper Cretaceous which are clearly related to them by their involute coiling, their apertures, and their ornamentation. The authors discriminate twelve genera, of which four are new: *Hedbergina* n. gen., *Ticinella* Reichel, *Thalmaninella* Sigal, *Praeglobotruncana* Bermudez, *Rotalipora* Brotzen, *Globotruncana*

Cushman, *Rugotruncana* n. gen., *Rugoglobigerina* Bronnimann, *Trinitella* Bronnimann, *Bucherina* n. gen., *Kuglerina* n. gen., and *Plummerita* Bronnimann. The phylogeny is discussed at length and illustrated graphically. "*Globigerina*"-like forms are assumed to have been ancestral to the group. *Globotruncana linneiana* (d'Orbigny) is rehabilitated and described on the basis of specimens collected from the sands of Havana Bay, Cuba. These specimens correspond closely to the form described by d'Orbigny in 1839 as *Rosalina linneiana*.

The authors asked me to present their work at the meeting of the Swiss Paleontological Society in September, 1955, and I therefore saw the manuscript before it was published. They indicated in their published preface that I had "critically read the entire manuscript," but the reader cannot tell whether or not my criticisms were accepted. Because our opinions on this subject still differ, it appears necessary to me to mention here some of the more important points on which I do not agree:

- 1) The shell structure of the Globotruncanidae is said to be "granular perforate," as contrasted with the observations of Wood, who considers it to be radiate perforate. In my opinion, the granular appearance of the microstructure of the test wall (not the external granulation) is caused by recrystallization disturbing the originally radiate structure, which is the same as in *Globorotalia*. I have been able to find distinct traces of the original radiate microstructure not only in the perforate part of the shell, but also in the imperforate parts, such as the keel, in all the genera of globotruncanids I have studied. It is especially clearly visible by polarized light.
- 2) Umbilical plates. The parts of the test that cover the umbilicus in the Globotruncanidae are called in this study "tongue-like extensions" in *Rotalipora*, and "umbilical cover plate" in *Thalmaninella*. The tongue-like extensions

are believed to be prolongations of the perforate shell wall, and the cover plate a special imperforate growth. This apparent difference causes the authors to separate the two genera radically. However, in thin sections we have not been able to find any essential difference. In the excellent illustrations given by the authors in text-figures 13-18, showing vertical sections of Globotruncanidae, the umbilical shell parts of the two genera show the same structure, that is, imperforate with a double wall (shown by the "dark line"). In one respect there is still a difference in morphology: The umbilical plate of *Thalmaninella* is attached to the wall of the chamber at an acute angle, whereas this angle is more obtuse in *Rotalipora* and has a tendency to disappear in the final chambers. This is especially true in the type species of *Rotalipora*, *Rotalipora turonica* (Brotzen), which was identified by Bronnimann as *Rotalipora cushmani* (Morrow). *Rotalipora apenninica* (Renz) also shows a rather sharp angle, and the accessory openings have an intra-umbilical position at the beginning of the last whorl. This fact would tend to show that the two genera are closely related and had a common origin.

- 3) The openings that appear around the system of lamellae forming the cover plate in *Globotruncana* s. str. (Bronnimann and Brown's text-fig. 7) are not supplementary openings, as they are in *Thalmaninella*. They are the openings of the helicoidal diaphragm, which is formed by the highly developed lips around the main openings. The term "supplementary opening" should be applied only to a second opening in any chamber. In the specimen figured by Bronnimann and Brown, of which I have the original, no other openings can be seen.
- 4) The identification of *Thalmaninella ticinensis* var. *alpha* (Gandolfi) (which accompanies *Thalmaninella ticinensis* in the upper Albian and lower Cenomanian of Europe and Africa) with *Thalmaninella*

multiloculata (Morrow), of the upper Cenomanian of Kansas, does not seem to me to be well founded.

- 5) The belief that *Praeglobotruncana stephani* (Gandolfi) and *Praeglobotruncana delrioensis* (Plummer) are synonymous is open to question. These forms are certainly very closely related, but the holotype of *Praeglobotruncana delrioensis* is less conical than *Praeglobotruncana stephani*. We shall not pursue the question of the identity of species any further, because these matters always involve subjective elements.

A. Carozzi, of Geneva, published a paper in 1954 (Archives des Sciences, vol. 7, no. 2) on a detailed study of the problematic form called "Organisme c" by J. Favre, from the Upper Jurassic. He made a three-dimensional reconstruction of these tests, and interprets them as the remains of a pteropod (*Vaginella striata* Carozzi).

In 1955, Carozzi described the dasy-clad microflora of the Upper Jurassic of the Geneva Basin (Eclogae Geol. Helv., vol. 48, no. 1). A similar paper on the Lower Cretaceous of the same region is in preparation.

H. R. Grunau and H. Studer, of Berne, recently reported on an electron-microscope examination of the microfossils of the Biancone limestone, of uppermost Jurassic to Barremian age (1956, Experientia, vol. 12, no. 4). *Nannoconus* was studied in detail and figured at an enlargement of 6000 \times .

G. Nicol of Berne mentions many microfossils, principally from the Jurassic and Cretaceous, in his thesis on the "Stockhorn-Kette" (published at Berne in 1956). He treats the Calpionellidae in considerable detail and presents a number of thin sections.

H. Schaub of Basel is actively carrying on his studies of European Nummulites. He has published an interesting preliminary note on the stratigraphic distribution of eight species of *Assilina* (1956, Eclogae Geol. Helv., vol. 48, no. 2).

In 1954, R. Verniory of Geneva published a careful revision of one of the problematic microfossils that Augustin Lombard attributed to sections of the thallus of algae and called *Eothrix alpina* (Archives des Sciences, vol. 7, no. 4). He shows that these fossils are sections of small segments of the arms of *Saccocoma*, a crinoid, which is abundant in the Upper Jurassic. One year later, Bronnimann, who had no knowledge of this note, described the same remains, which he had found in Cuba, as *Lombardia* n. gen. incertae sedis (Micropaleontology, vol. 1, no. 1, 1955). In another paper, Verniory (1956, Archives des Sciences, vol. 9, no. 1) rejects Bronnimann's new name, pointing out that this is by no means an entire organism, but merely separated parts of a well known crinoid. We may add that some of these sections may represent ossicles of some ophiurid, which are also common in the Malm. The latter opinion is held in particular by Z. Reiss of Jerusalem, as he indicated to me on his recent visit to Basel. In 1956, Verniory also published a note on the Upper Jurassic and Lower Cretaceous of the Euganean Hills, Padua, reporting *Saccocoma* and tintinnoids (Archives des Sciences, vol. 9, no. 1).

R. Murat and G. Scolari of Geneva have reported on the occurrence and stratigraphic distribution of *Pfenderina neocomiensis* (Trochamminidae) in the Lower Cretaceous of the Jura Mountains and the autochthonous Alps (1956, Archives des Sciences, vol. 9, no. 1).

Your correspondent has continued to work on the projects indicated in his last report (October, 1954), but he has not yet completed any of them because of the press of other activities. He recently published a note on *Trocholina* from the Valanginian of Arzier (1956, Eclogae Geol. Helv., vol. 48, no. 2). He will be in Athens during the last three months of 1956, acting as a UNO expert in micropaleontology at the Greek Institute of Geology and Subsurface Research.

At the Geological Institute of Basel, Lucas Hottinger is working on a

thesis on the Alveolines of the Eocene. It will involve a revision of the systematics and stratigraphic distribution of these forms, which has long been needed.

The thesis of H. Oertli of Berne, on the ostracodes of the molasse of Switzerland, is now in press (Schweiz. Pal. Abh., vol. 74). It is expected to appear within the next few months.

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UNITED STATES — MID-CONTINENT REGION



DOROTHY JUNG ECHOLS

The Mid-Continent news report for "Micropaleontology" includes the following states: North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, Missouri, Oklahoma and Arkansas. Your correspondent has attempted to contact all universities and colleges in these states that might be interested in or actively engaged in micropaleontologic research. Since there are undoubtedly many laboratories doing this work that have not been reached in the original letters, your correspondent would greatly appreciate communications from these laboratories, so that they might be contacted for news in future reports.

University of Oklahoma
Norman, Oklahoma

Dr. R. W. Harris reports the following news items: Irwin Gold has completed his master's thesis, en-

titled "Foraminifera from the Marlbrook formation of southwestern Arkansas." The following publications are now in press: R. W. Harris, "Simpson Ostracoda of Oklahoma," and Harris and McNulty, "Observations on *Gyroidina cretacea* in the Upper Cretaceous."

The Oklahoma Geological Survey has recently published "Chester foraminifera and Ostracoda from Ringwood pool," by Harris and Jobe (1956, Circular 39). In this publication, three foraminifera and twenty-seven Ostracoda are described and illustrated from the producing "Manning" horizon of the Ringwood oil pool of Oklahoma. Thirteen of the ostracode species have been reported from Mississippian (Chester) strata of Illinois. Eleven new species and three new varieties of Ostracoda serve to corroborate the assigned age of Upper Mississippian for the "Manning" zone.

Another Oklahoma Geological Survey publication is "Plant microfossils of the Croweburg coal," by Wilson and Hoffmeister (1956, Circular 32). In this paper, fossil spores and leaf cuticles of the Croweburg coal of Pennsylvanian (Desmoinesian) age from nine localities in northeastern Oklahoma are described and statistically treated for purposes of stratigraphic correlation. "Spores of McAlester coal," by J. L. Morgan, was issued as Oklahoma Geological Survey Circular 36 (1955). This study is an attempt to utilize the spore-count method to correlate certain coal beds in the McAlester basin with coals of the shelf area.

**Oklahoma Agricultural and Mechanical College
Stillwater, Oklahoma**

Dr. V. Brown Monnett writes: "Although we are contemplating offering work in micropaleontology, we have not done so yet. We have no research going on in this field."

**University of Tulsa
Tulsa, Oklahoma**

Dr. Edward Heuer reports that class work and research in micropaleontology is continuing at the university. At the present time there are no current news items to report.

**University of Wichita
Wichita, Kansas**

A most interesting letter was received from Professor Paul Tasch, who is now teaching at the University of Wichita. His comment regarding the importance of "Micropaleontology" is so true for all of us engaged in micropaleontological work that I would like to quote it before discussing news from Wichita. "In our micropaleontology course, several articles in the journal 'Micropaleontology' are reported on by students, so it is not mere archive or future reference material, but living stuff to be used now, and even in training students." At the University, Dr. Tasch has established a one-year sequence in paleontology for undergraduates. The second semester is devoted to detailed micropaleontological study, including identification of fusulinids in thin section, foraminiferal suites from representative areas, ostracodes and conodonts. At present there is one master's student, John Quick, working under Dr. Tasch's sponsorship on a problem relating to sedimentary aspects of certain Permian fusulinid-bearing horizons. The emphasis is on fusulinids as sediment contributors. This is a pilot study on a problem not previously explored, and if results warrant it, it will be further expanded to fusulinid horizons elsewhere. Dr. Tasch says: "My own research includes a continuation of study of the microfauna of the Maquoketa depauperate zone of Iowa, based on surface collections, and including subsurface material from Missouri and Illinois. This research has been sponsored by an initial National Science Foundation grant for field work, and a current one for this year, for hiring laboratory assistants. Students who have had my paleo classes are employed doing preparatory work on samples.

"I might mention that our department has at least one fellowship (stipend \$1300) available for next year, for any suitable applicant holding a B.A. or B.S. with major in geology. Individuals who hold the undergraduate degree, and who have been working in the oil industry in micropaleo labs, will find

this an exceptional opportunity to work on a micropaleo master's problem while on a teaching fellowship. Interested persons can apply by writing to Professor J. R. Berg at the University of Wichita." Dr. Tasch is interested in enlarging his micropaleontological collections, and is quite willing to offer exchange material.

**The University of Kansas
Lawrence, Kansas**

A letter from Dr. Richard Benson during the summer of 1956 reports the following news items: "We are very much engaged in working with the ostracodes here, both on the Treatise of Paleontology and many other smaller works. I have just finished an ecological study of the Recent ostracodes of Todos Santos Bay in Baja California in cooperation with Scripps Institute of Oceanography, which will be presented at the Mexico Congress in September; and am just starting a similar study of the Florida Keys region. Also I have several students working on a Recent and Cenozoic topotype collection, as well as a Ph.D. student much interested in fresh-water Pleistocene ostracodes. Dr. Sylvester Bradley of England has spent a year with us working on the treatise and imparting some of his vast knowledge of Mesozoic and Cenozoic ostracodes to us."

**University of North Dakota
Grand Forks, North Dakota**

Professor Wilson Laird reports the following news items: "At the 1955 Geological Society of America meeting, Professor F. D. Holland and Charles H. Waldren (now with the Carter Oil Company at Miles City, Montana) gave a preliminary report on a conodont fauna from the basal sandstone unit of the Winnipeg formation in the subsurface of the Williston Basin. Their study indicated that this portion of the Winnipeg is at least as old as Blackriveran or Chazyan. More conodonts are being collected from the Winnipeg, but because of other work, the study is being temporarily delayed.

"Everett E. Wilson, graduate assistant in the department, has made

collections and begun a study of the microfauna of the Pierre shale of North Dakota as a thesis under the direction of Mr. Holland. Wilson is also studying the small solitary corals of the Cannonball formation. Collections of foraminifera from the Niobrara and Benton and ostracodes of the Fort Union are awaiting study."

**State University of Iowa
Iowa City, Iowa**

Professor W. M. Furnish contributes the following items of interest: "Klaus J. Müller, research associate on a National Academy of Science fellowship for two years, is now enroute back to Berlin and his previous position at the Technische University, Berlin-Charlottenburg. Müller's main interest while here was Upper Devonian conodont faunas. His monograph of *Palma-tolepis* and related forms is soon to be published, and additional faunal studies from the central United States are near completion. In addition, he has in press a survey of the stratigraphic occurrence of conodonts, including the first record of these fossils in an established Upper Cambrian sequence.

"Abdullah S. Sayyab completed his study of Cretaceous ostracodes of the Persian Gulf area and accepted a position with the Directorate General of Oil Affairs in Bagdad. Anne Marie Treloar Glenister has submitted for publication her study of Iowa Maquoketa (Upper Ordovician) conodonts. Brian F. Glenister reports from the University of Western Australia that new discoveries in the Devonian show that conodonts are more abundant and widespread in occurrence there than previously realized. Raymond L. Ethington is progressing with recovery of conodont faunas from the Ordovician Galena group in the Upper Mississippi Valley. A few other similar projects are in an early stage."

**The University of Nebraska
Lincoln, Nebraska**

Walter Sadlick, who is now teaching paleontology at the University of Nebraska, reports the following

news items: "Last year no official course work was given in micropaleontology, since Dr. B. Burma left the university to work for the California Exploration Company in San Francisco. Although I am still a Ph.D. candidate in the Department of Geology, I was appointed an instructor in the department. I have a manuscript circulating in the mail dealing with proposed Lower Pennsylvanian fusulinid zones. This paper was written as a supplement to the Geological Society of America Pennsylvanian correlation chart, which mentions Lower Pennsylvanian fusulinids only briefly.

"In the foraminiferal laboratory a study of the oscillations of the Niobrara formation of northeastern Nebraska was initiated. It is hoped that the Fort Hays-Smoky Hill member contacts can be selected by Israelsky's method."

**University of Missouri
Columbia, Missouri**

Dr. Raymond E. Peck reports: "There is a great deal of micropaleontological activity at the University of Missouri this winter. Dr. M. G. Mehl has under way a long-range biometric study of late Devonian conodonts, and Dr. Peck has completed a monographic study of North American Mesozoic Charophyta, which has been approved for publication as a U. S. Geological Survey Professional Paper. He is at present engaged in a detailed stratigraphic study of Morrison microfossils to determine whether or not it is possible to differentiate the Salt Wash sandstone and Brushy Basin shale equivalents in the undivided Morrison of central Colorado and Wyoming.

"Student activities include Ph.D. dissertations: 'Upper Jurassic microfaunas of Saskatchewan,' by John Wall, and 'An analysis of the spores and pollen of the Frontier (Cretaceous) of the Wind River Basin,' by Charles Upshaw; and master's theses: 'Possibility of correlation of lower Marmaton (Pennsylvanian) strata by use of conodonts,' by Robert Klausling, 'Conodont faunas of the Reed Spring (Mississippian) formation,' by Yusuf Farris, 'A new

conodont fauna from below the Callaway group (Mid-Devonian),' by Cordell Johnson, 'Conodont evidence on the basal relations of the Mississippian of central Missouri,' by Regis Haller, 'The age and correlation of isolated black shale outcrops in southeastern Missouri, based on conodont evidence,' by Virginia Smoot, and 'The foraminifera of Paynes Hammock (Miocene) formation of southeastern Mississippi,' by William Allen. Other papers currently in preparation are 'The ostracod fauna of the Louisiana limestone (Mississippian) of north-eastern Missouri,' by Walter Niewoehner, and 'The ostracod fauna of the Reed Spring formation of southwestern Missouri,' by George Fraunfelder."

**Saint Louis University,
Saint Louis, Missouri**

Dr. Kenneth Brill reports that Leo Emmett is doing a master's thesis on Bryozoa from the Warsaw formation of the Mississippi Valley region.

**Washington University
Saint Louis, Missouri**

The School of Botany is currently engaged in three paleobotanical studies. Dr. Andrews, with the assistance of Bill Murdy and Karen Alt, is investigating an extinct problematic plant group (questionably *Foerstia*), whose small disc- or Y-shaped remains occur in strata of the east-central states; the study was initiated in the fall of 1955 on samples of New Albany shale (Upper Devonian to Lower Mississippian). Dr. Andrews intends to use a portion of a National Science Foundation grant awarded to him in June for the Paleozoic part of this investigation, the results of which he expects to be published in November or December.

Using coal-ball material, Bill Murdy is working on the primitive fern *Botryopteris*. Thin-section investigation of a petrified, unique early land-plant, with semipermanent woody tissue unlike that of any other plant, is also under way.

In the Department of Micropaleontology there is considerable activity. This year we have a few new

students who we believe will make fine, enthusiastic micropaleontologists. In June, 1956, Harold Levin was awarded his Ph.D. degree; his thesis, entitled "Micropaleontology of the Oldsmar (Lower Eocene) limestone of Florida," is now being prepared for publication in "Micropaleontology." He is now working for the Standard Oil Company of California, at Bakersfield, California. Currently, he writes, he is doing a great deal of sedimentology, proving what we have always advocated—that a good "bug" man must be versatile.

Wayne Hill, master's candidate for February, 1957, is hard at work on the ostracodes of the Platin formation (Ordovician) of Missouri. He has made extensive collections from various zones in the Platin within a radius of fifty miles of St. Louis. Eventually we hope to publish this study.

Katherine Schaeffer, master's candidate, is a graduate teaching assistant this year. She is currently doing research on techniques for extracting "microforaminifera," spores, and pollen from various kinds of sediments. This preparatory work is being done in connection with her thesis problem. Her thesis will be done on the "microforaminifera" and spores of some Eocene samples collected by the Sun Oil Company. She hopes to have an opportunity to visit their laboratory during her investigation and work under Dr. Charles Felix.

Research projects are currently being undertaken on the microfauna of Miocene? (Pliocene?) sediments from Venezuela; on Recent bay and ocean beach sediments of Long Island; a manual of ostracod genera; a check list of Pennsylvanian and Permian ostracod genera and species; Nanafalia (Lower Eocene) ostracods; and a quantitative study of microfaunas from two Cretaceous wells.

A short note on Fern Glen ostracodes by Echols and Gouty is in press, to be published in the "Journal of Paleontology." This article is a supplement to Dr. Richard Benson's

Fern Glen ostracode paper (1955, Jour. Pal., vol. 29, pp. 1030-1040).

Among visitors to our laboratory this past year were Mrs. Betty Kellett Nadeau, who now lives in Buffalo, New York; Dr. Charles Felix, who is now with the Sun Oil Company research laboratory in Dallas, Texas; Bill Creath, of Stanolind Research Division, in Tulsa, Oklahoma; and Paul Beach, micropaleontologist with Standard of Texas, in Houston, Texas.

DOROTHY JUNG ECHOLS
Washington University
Saint Louis, Missouri

WEST INDIES



PAUL BRONNIMANN

TRINIDAD

A. Wirz left Trinidad Petroleum Development Ltd. in August, 1956, and joined the Cuban Stanolind Oil Company in Havana, where he is in charge of the new geological laboratory. Trinidad Leaseholds Ltd. has changed its name to The Trinidad Oil Company Ltd., and recently was sold to The Texas Company. W. H. Blow has left Trinidad Leaseholds, and is now with the Department of Geology, Burbeck College, University of London. As a result of his scientific studies in Trinidad, he published an interesting paper (1956, Micropaleontology, vol. 2, no. 1, pp. 57-70) on the evolution of the genus *Orbulina* d'Orbigny through the sequence *Globigerinoides triloba* → *Globigerinoides bisphérica* → *Globigerinoides glomerosa* → *Orbulina suturalis* → *Orbulina universa*. He introduced

a new genus, *Biorbulina*, for *Orbulina bilobata*. He believes that *Biorbulina* was derived through another lineage from *Globigerinoides biloba*. The evolution of *Orbulina* and *Biorbulina* is convincingly demonstrated by transitional forms of *Globigerinoides*. However, the splitting of *Globigerinoides glomerosa* into three subspecies appears to be rather artificial.

H. J. Beckmann is working on Tertiary Gumbelinas, and J. B. Saunders has revised the taxonomy of some of the Recent foraminifera of the Gulf of Paria originally described by Cushman and Bronnimann (1948, Contr. Cushman Lab. Foram. Res., vol. 24, pp. 15-21). H. G. Kugler submitted to your correspondent some Upper Jurassic limestones from the Northern Range of Trinidad, containing *Favreina*, a problematic microfossil classified by Paréjas and Cuvillier as coproliths of crabs.

H. V. Kaska, who was formerly in charge of the geological laboratory of the Dominion Oil Company in Port-of-Spain, has been in San Francisco with the California Exploration Company since May, 1956. He has been succeeded here by H. E. Stacy, who is assisted by E. Nieves and M. Polugar, both from New York University. L. Martin has returned to Stanford University on special leave from the company to work for his Ph.D. A. R. Loeblich of Washington, and W. Maync, formerly of Caracas and now with the Compagnie d'Exploration Pétrolière in Chambourcy, France, recently visited the laboratory of the Dominion Oil Company.

BARBADOS

The Gulf Oil Corporation is continuing drilling in Barbados. Well and surface samples are being studied by the laboratory of the Cuban Gulf Oil Company in Havana.

JAMAICA

Jamaican Stanolind's surface and well material is being processed and investigated paleontologically by the Havana laboratory of the Cuban Stanolind Oil Company. Your correspondent has done some work for

L. J. Chubb and H. R. Versey of the Geological Survey of Jamaica. W. Storrs Cole has published two notes in which larger foraminifera from Jamaica are described (1956, Bull. Amer. Pal., vol. 36, nos. 158 and 159).

H. R. Hose and H. R. Versey, in a paper entitled "Paleontological and lithological divisions of the Lower Tertiary limestones of Jamaica" (1956, Colonial Geology and Mineral Resources, vol. 6, no. 1, pp. 19-39), discuss six foraminiferal zones in the Yellow and White Limestone formations of Jamaica. The zones are established on the following diagnostic forms, from bottom to top: 1) *Lituonella* sp. A; 2) *Lepidocyclina antillea*; 3) *Lepidocyclina macdonaldi*; 4) *Lepidocyclina undosa-Lepidocyclina favosa* group; 5) *Miogypsina antillea*; 6) *Amphisorus matleyi*. The paper is illustrated by excellent photographs of thin sections showing the microfauna and the petrofabric.

CUBA

During the period under review, the Cuban Stanolind Oil Company and the Cuba California Oil Company organized geologic laboratories in Havana. The Stanolind laboratory is staffed by A. Wirz and W. R. Weaver, who was formerly with the Richmond Exploration Company in Maracaibo. Weaver is engaged in the study of Jamaican material, and Wirz mainly with samples from Cuba.

P. Norton and M. Furrer are at present doing micropaleontologic work on samples from Cuba and the Bahamas for the Cuba California Oil Company. Norton is from the University of California at Berkeley, and, prior to his Cuban assignment, worked for the Standard Oil Company of California in San Francisco. Furrer, from the University of Basel, Switzerland, worked from 1950 to 1955 as a micropaleontologist with the Iran Oil Company, and from 1955 to 1956 as a research associate with H. E. Thalmann at Stanford University, California. Since August, 1956, he has been on a temporary assignment in Cuba.

There are no changes in personnel to be reported for the Cuban Gulf Oil Company. The Havana laboratory is handling material from Cuba, Barbados, British Honduras, Puerto Rico, Jamaica, and the southern United States. Within the last year, the laboratory has received visits from H. H. Renz, of the Mene Grande Oil Company, Caracas; G. Murray, of Louisiana State University, Baton Rouge; H. A. Lowenstam, of the California Institute of Technology, Pasadena; P. J. Bermudez, of the Creole Petroleum Company, Jusepín; Morton B. Stephenson, of the Stanolind Oil Company, Tulsa; and Victor E. Benavides Cáceres, of the International Petroleum Company, Lima.

Your correspondent has published notes on pseudorbitoids, in which two new genera, *Rhabdorbitoides* and *Historbitoides*, were described. This work on Upper Cretaceous larger foraminifera is being continued. A joint paper with N. K. Brown, Jr., on the taxonomy of the Globotruncanidae, appeared in 1956 (Eclogae Geol. Helv., vol. 48 (1955), no. 2, pp. 503-561). In this paper, the family Globotruncanidae Brotzen, 1942, is defined, with the following twelve genera, of which four are new: *Globotruncana*, *Praeglobotruncana*, *Rotalipora*, *Ticinella*, *Thalmanninella*, *Rugoglobigerina*, *Trinitella*, *Plummerita*, *Hedbergina* n. gen., *Rugotruncana* n. gen., *Kuglerina* n. gen., and *Bucherina* n. gen. All of these genera are believed to have been derived from "*Globigerina*"-like ancestors by one or a combination of the following modifications of the later chambers: Dorsoventral compression and formation of a peripheral imperforate band; development of large apertural flaps which form umbilical cover plates; development of costellae; change in shape. In this morphologic study, an attempt has been made to develop a unified classification of the Globotruncanidae. Five new species are described: *Rugotruncana tilevi*, *Rugotruncana ellisi*, *Rugotruncana skewesae*, *Rugotruncana nothi* and *Bucherina sandidgei*, and a neotype selected for *Globotruncana*

linneiana (d'Orbigny). Special attention is devoted to the synonymies of the various forms.

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YUGOSLAVIA

The earliest mention of microfossils in Yugoslavia was published by Pavlović (1911). Since that time, a large number of Yugoslavian geologists have made use of micropaleontology in the solution of geological problems. Luković (1922) reported foraminifera from the Second Mediterranean stage in the vicinity of Belgrade. Dimitrijević (1931), in a paper entitled "Petrographic and mineralogical study of the Avala," recorded foraminifera from the beds of that area. Milovanović (1935) published a paper on *Lofusina morgani* Douvillé, and Stepanović (1938) studied the microfauna of the Upper Miocene in the vicinity of Belgrade.

However, it was not until 1947 that a separate department of micropaleontology was established in what was then called the "Zavod za Geoloska Ispitivanja" of the Yugoslavian Ministry of Mines. This department was under the direction of the well known German micropaleontologist Professor Dr. Carl A. Wicher, to whom the geologist Sultana N. Obradović was assigned as first assistant. With the establishment of this department, productive activity in applied micropaleontology began in Yugoslavia, and from then on it has never been interrupted and is still expanding today. The first step was to set up a laboratory for the processing of samples and to institute all the organizational procedures necessary in order to carry on systematic scientific work. A flood of samples from shallow and deep borings as well as from outcrops began to come in, indicating that this department answered an urgent need in applied micropaleontology.

The brackish-water Pliocene of the Pannonian Basin was subdivided on the basis of its microfauna, and

the Paludina beds (Levantine) were separated into the ostracode-bearing upper and middle Paludina beds, and the lower Paludina beds, which contain three or four species of megaspores. In Banat, structures in the lower Paludina beds in shallow borings were mapped (for example, at Sabač, Kikina, Velika Greda, Beće, etc.). Micropaleontological subdivisions were established in the Pannonian, for example, the upper and lower Rhomboidea beds, the Abichi beds 4, 3, 2, and 1, and the Praevalenznesia beds 1 and 2. A diatom horizon that extends from the base of the Abichi beds into the upper Praevalenznesia beds was precisely determined.

Besides these questions, which are important in petroleum geology, the following subjects were also studied: The immediate and the more remote environs of the Avala (reef facies of the Lower Cretaceous, first discovery of the Upper Cretaceous here); the "Gosau" beds of Topčider were shown to be of Hauterivian age; in Alexinac (Logorište), brackish-water Oligocene was found; on Mount Fruška, Maestrichtian; at Jabukovac, Tortonian; at Repište, Lower Cretaceous reef facies; at Senski Rudnik, lower Hauterivian; and in Macedonia, Pliocene. This is merely a brief sketch of our activities during this period. In the course of such intensive work in applied micropaleontology, it was, of course, scarcely possible to think of publication.

In August, 1950, Dr. Wicher returned to Germany, but he is still, however, in close contact with Yugoslavian micropaleontology, as is shown by his status as a member of the Serbian Academy of Sciences. Katarina Veljković has been working with Sultana N. Obradović since the end of 1949, and Radojka Džodžo since 1950. All three geologists are now on the staff of the "Jovan Zujović" Geological Institute of the Serbian Academy of Sciences.

A micropaleontological service has also been established in the Geological and Paleontological Department of the University of Zagreb, where

geologists Wanda Kohansky-Devidé and Donata Nedela-Devidé are engaged in micropaleontological work. Geologists Vera Ammel and Claviča Mildini are also working as micropaleontologists for the Croatian Geological Institute in Zagreb. In Ljubljana, Juliana Rijaveč, and more recently also Katarina Veljković of the Serbian Academy of Sciences in Belgrade, have been active as micropaleontologists with the Slovenian Geological Survey. Since the end of 1954, micropaleontological work has also been carried on at Naftagas in Novi Sad by Vera Marković, and at Nafta Montenegro by Miruna Čanović. Recently, Vera Temkova has been working in the field of micropaleontology in Skopje, Macedonia, and Vera Momić in Tuzla, Bosnia and Hercegovina.

The most important work carried on by the various micropaleontological laboratories has been research on cores from oil wells and from shallow borings in different parts of Yugoslavia. To name some examples: In Croatia, predominantly Miocene and Pliocene samples have been studied; in Vojvodina (Serbia), Miocene, Pliocene and Upper Cretaceous; in Kocovo Polje, exploratory borings penetrating Pliocene to Oligocene strata; in Bosnia and Hercegovina, Tertiary (Eocene and Pliocene) and Upper Cretaceous; in Slovenia and Montenegro, Eocene, Cretaceous and Jurassic; and in Macedonia, Eocene to Pliocene.

In addition to cores from exploratory borings, outcrop samples have been collected from all parts of Yugoslavia, and studied from a micropaleontological point of view. This has been done principally in areas where there are no megafossils. The results are presented in part in the "Geological Annals of the Balkan Peninsula" and in the publications of the Geological Institute of the Serbian Academy of Sciences.

Further studies will be: The Cretaceous and Tertiary of the environs of Belgrade and Schumadija; the Tertiary of Golubac (Serbia); the

Triassic and Jurassic of Vares (Bosnia and Hercegovina); the Upper Cretaceous and Tertiary of Mount Fruška (Vojvodina); the Upper Cretaceous flysch of western Serbia; the Buglov beds of eastern Serbia; the Upper Cretaceous to Tertiary flysch of Montenegro; the Upper Cretaceous of Bor; the Neoschwagerina beds and their fusulinid fauna (Slovenia); the Bellerophon beds, *Globotruncana*-bearing strata of Croatia and Montenegro; the Miocene and Pliocene of Croatia; and the later Tertiary of the Tuzla Basin (Bosnia and Hercegovina).

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